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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 95.

L. O. HOWARD, Entomologist and Chief of Bureau.

159

PAPERS ON CEREAL AND FORAGE INSECTS

CONTENTS AND INDEX.

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 95.
L. O. HOWARD, Entomologist and Chief of Bureau.

PAPERS ON CEREAL AND FORAGE INSECTS.

I. THE TIMOTHY STEM-BORER, A NEW TIMOTHY INSECT.
By W. J. PHILLIPS, *Entomological Assistant.*

II. THE MAIZE BILLBUG.
By E. O. G. KELLY, *Entomological Assistant.*

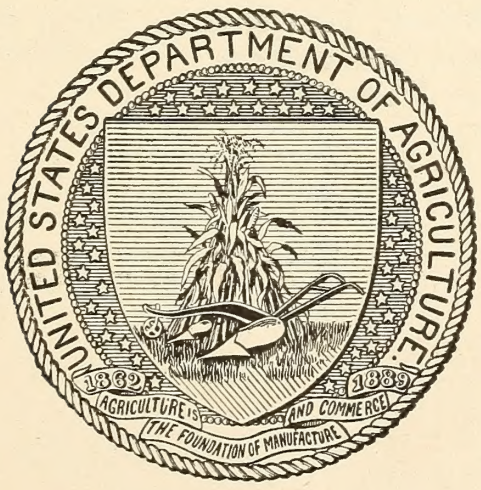
III. CHINCH-BUG INVESTIGATIONS WEST OF THE MISSISSIPPI RIVER.
By E. O. G. KELLY, *Entomological Assistant,*
AND
T. H. PARKS, *Entomological Assistant.*

IV. THE SO-CALLED "CURLEW BUG."
By F. M. WEBSTER, *In Charge of Cereal and Forage Insect Investigations.*

V. THE FALSE WIREWORMS OF THE PACIFIC NORTHWEST.
By JAMES A. HYSLOP, *Agent and Expert.*

VI. THE LEGUME POD MOTH.
THE LEGUME POD MAGGOT.
By JAMES A. HYSLOP, *Agent and Expert.*

VII. THE ALFALFA LOOPER IN THE PACIFIC NORTHWEST.
By JAMES A. HYSLOP, *Agent and Expert.*



WASHINGTON:
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1913.

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Nettie S. Klopfer, Ellen Dashiell, *preparators.*
Chas. Petty, *collaborator.*

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., December 11, 1912.

Sir: I have the honor to transmit herewith, for publication as Bulletin No. 95, seven papers dealing with cereal and forage insects, and methods for their control. These papers, which were issued separately during the years 1911 and 1912, are as follows: The Timothy Stem-Borer, by W. J. Phillips; The Maize Billbug, by E. O. G. Kelly; Chinch-Bug Investigations West of the Mississippi River, by E. O. G. Kelly and T. H. Parks; The So-Called "Curlew Bug," by F. M. Webster; The False Wireworms of the Pacific Northwest, by James A. Hyslop; The Legume Pod Moth and The Legume Pod Maggot, by James A. Hyslop; The Alfalfa Looper, by James A. Hyslop.

Respectfully,

L. O. Howard,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The articles included in this bulletin relate to insects more or less destructive to cereal and forage crops in the United States. They represent investigations largely completed during the fiscal year 1911–12.

The timothy stem-borer, the subject of Part I, has not during our observations been especially injurious, but is likely to become so should several favorable conditions result in increased abundance. The maize billbug (Part II) and the so-called "curlew bug" (Part IV) are two very closely related insects, the latter being especially destructive in Virginia and the Carolinas, while the former is occasionally quite injurious in the West. The paper relating to chinch-bug investigations west of the Mississippi River (Part III) is exceedingly timely and serves to make more clear the difference in conditions, as regards the chinch bug, between the country west of the Mississippi River and that lying east of it. Parts V, VI, and VII relate to species more or less destructive in the extreme northwestern portion of the United States, a section of the country somewhat peculiar in that it differs greatly in insect fauna from more southern and eastern sections of the country.

All of these papers relate to insects that the farmer must, to a greater or less extent, encounter and control in a successful carrying out of his business.

F. M. Webster,
In Charge of Cereal and Forage Insect Investigations.

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[1] The seven papers constituting this bulletin were issued in separate form on March 31, April 22, and December 14, 1911, and April 10, April 22, May 31, and October 16, 1912, respectively.

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ERRATA.

Page 2, line 18 from bottom, for *this year* read *in 1910.*

Plate I, facing page 8, after line at bottom, insert: *a, Work of larva in bulb of plant; b, larva ascending stem to pupate; c, pupa in cell, the gallery plugged with frass below. Much enlarged.* (*Original.*)

Page 12, line 19 from bottom, before *corn borer* insert double quotation mark in place of single quotation mark.

Page 15, line 16, for *were* read *was.*

In Plate IV, facing page 24, the cut of figure 1 is upside down.

Page 46, line 16 from bottom, after *4* insert *per cent.*

Page 74, last line, insert superior figure 1 ([1]) before *Bureau.*

Page 76, line 16 from bottom, for *littorale* read *aviculare.*

Page 77, line 12 from bottom, for *littorale* read *aviculare.*

Page 81, line 4, after *monograph* insert comma.

Page 81, line 5 from bottom, before *Dr.* insert *of.*

Page 82, line 5 from bottom, for *littorale* read *aviculare.*

Page 83, line 8, for *littorale* read *aviculare.*

U. S. D. A., B. E. Bul. 95, Part I. C. F. I. I., March 31, 1911.

PAPERS ON CEREAL AND FORAGE INSECTS.

THE TIMOTHY STEM-BORER, A NEW TIMOTHY INSECT.

(*Mordellistena ustulata* Lec.)

By W. J. Phillips,
Entomological Assistant.

INTRODUCTION.

The writer's attention was first attracted, in 1904, to the interesting little insect which is the subject of this paper. On November 29 of that year, at Rives, Tenn., while examining timothy for joint-worms (Isosoma), a curious little larva, unknown at that time to the writer, was found tunneling the stems. In many cases it had traversed the entire length of the stem, from the top joint to the bulb. Although nothing was reared from this material it served to arouse interest. Since that time, however, it has been reared and some interesting facts learned concerning its habits and manner of living.

Thus far it has not proved a serious pest, having been found only in small numbers at any given point. In large numbers it would scarcely do any perceptible injury to the hay crop, although it could probably very materially lessen seed production. For this, as well as other reasons, it deserves more than passing notice.

HISTORY.

The adult (fig. 1) was described by Le Conte in 1862, but there is no reference in literature to its larval habits, although as early as 1877 it was known that larvæ of other species of this genus inhabited plant stems of different kinds.

During the early part of November, 1904, Mr. Geo. I. Reeves, of this Bureau, found larvæ tunneling timothy stems at Richmond and Evansville, Ind., and at Nicholsville, Ohio, but none was reared. In the latter part of the month the writer found a larva working in timothy stems at Rives, Tenn. Nothing could be reared, but in the light of recent observations it is very probable that they were *Mordellistena ustulata* in each instance.

In 1905 the writer found numbers of larvæ inhabiting timothy at Richmond, Ind. Some time in the fall infested stems were collected and sent to the Department for rearing, but it was the same story—nothing issued.

Early in the spring of 1906 observations were begun with a view to rearing the adult. Infested stems were collected in May, and on June 8 the first adult appeared. Specimens were later submitted to the Department and were found to belong to the above species. Since that time they have been reared repeatedly.

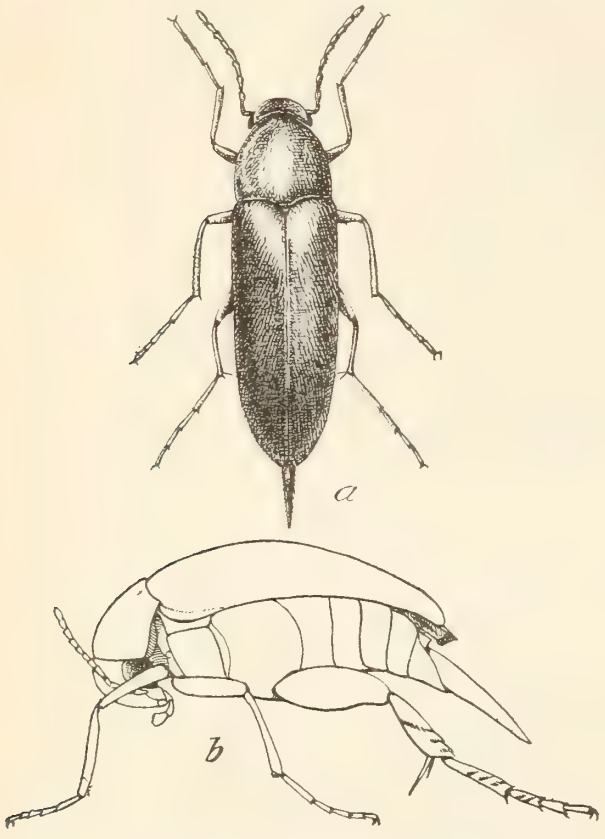

FIG. 1.—The timothy stem-borer (*Mordellistena ustulata*): *a*, Adult or beetle, dorsal view; *b*, same, lateral view. Greatly enlarged. (Original).

DISTRIBUTION.

The habitat of this insect has been given as the middle and southern United States. Adults have been captured as far east as Pennsylvania, and they have been reared from material collected in Indiana, Ohio, and Virginia. Timothy stems containing mordellid larvæ that were not identified, but which were probably *Mordellistena ustulata*, were found in Kentucky, Tennessee, Illinois, and, this year, Mr. T. H. Parks, of the Bureau of Entomology, found them at Chillicothe, Mo.

CHARACTER OF ATTACK.

As a rule the egg is deposited at or slightly below the center of the first or second joint in timothy, but much farther down the stem in other grasses. From here the larva bores into the center of the stem and then begins its downward journey to the bulb or root. It feeds upon the pith and the walls of the stem as it passes downward, and when it encounters a joint it tunnels completely through it, leaving a mass of detritus behind. Plate I is an illustration of its workmanship.

HOST PLANTS.

This species has been reared from timothy, orchard grass (*Dactylis glomerata*), quack grass (*Agropyron* sp.), and *Agrostis alba*, while larvæ that were supposedly this species have been found in bluegrass (*Poa* spp.) and cheat (*Bromus secalinus*).

DESCRIPTION OF THE DIFFERENT STAGES.

THE EGG.

(Fig. 2.)

Length 0.65 mm., diameter near center 0.16 mm. Color milky white. Acuminate-ovate, apparently smooth; one side convex and the other slightly concave; large end broadly rounded, small end acutely rounded.

Described from specimens dissected from gravid females.

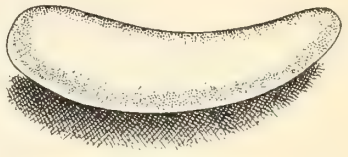

FIG. 2.—The timothy stem-borer: Egg. Highly magnified. (Original.)

THE LARVA.

(Fig. 3, *a*.)

Length 6 mm., diameter 0.875 mm. Color varying from creamy to white, shading into a very faint tinge of salmon near center. None of the segments appears to be corneous, although each bears a number of setæ; last segment feebly bifid, ending in a two-pointed spear, and covered with stout bristles. Dorsal surface of abdomen with six pairs of fleshy tubercles which will be described later.

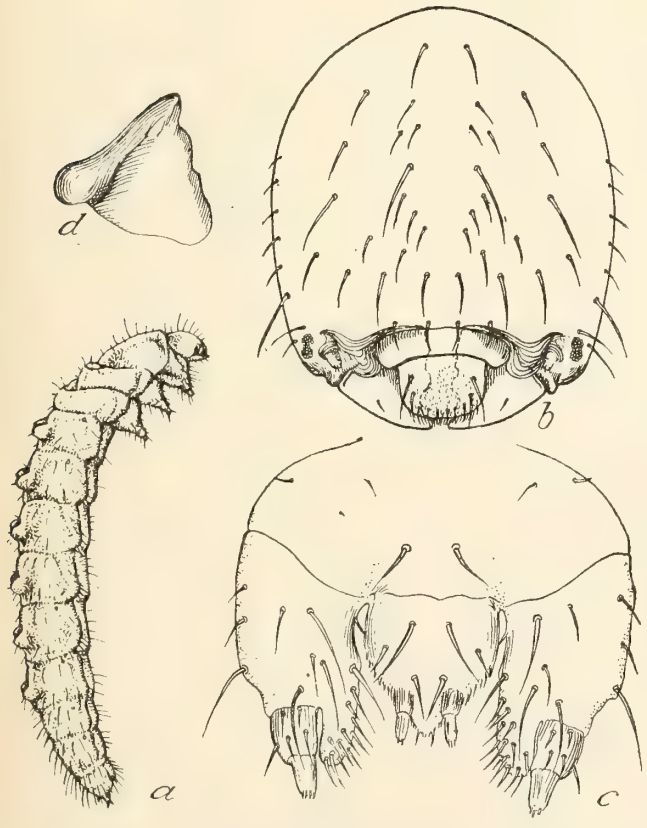

FIG. 3.—The timothy stem-borer: *a*, Larva, lateral view; *b*, head of same, dorsal view; *c*, maxillæ and labium of same; *d*, mandible of same. *a*, Greatly enlarged; *b*, *d*, more enlarged; *c*, still more enlarged. (Original.)

Head (fig. 3, *b*) narrower than thorax and arranged almost vertically with reference to it; ovoid, smooth, and bearing a number of large and small setæ, a very faint suture extending from the occipital area almost to the epistomal area.

Antennæ represented by two fleshy tubercles, situated laterad of and near insertion of mandibles; somewhat cone-shaped and bearing several small setæ on their summits.

Eyes represented by two tiny, slightly fused black dots situated slightly ventro-laterad of the antennæ.

Epistoma sublunate; anterior margin concave and posterior convex; about twice as broad as long and apparently inclosed by base of mandibles and a chitinous ridge extending from insertion of mandibles almost entirely across the face; ridge amber-colored.

Labrum tonguelike, lying directly over the mandibles, rectangular, longer than broad; distal margin rounded and densely fringed with setæ or bristles; upper surface pappose; two large setæ near center and two on each lateral margin; six smaller ones on distal margin.

Mandible (fig. 3, *d*) short, very broad at base, almost as broad as long, tapering abruptly to a sharp point; outer face convex and smooth, with a small seta near center; ferruginous at base and black at extremity, strongly curved; inner face concave, with two small notches midway of superior margin and one small notch near extremity of inferior margin.

Maxillæ (fig. 3, *c*) inserted far to the rear, large, fleshy, curving considerably, thus inclosing the labium; extending considerably beyond tips of mandibles; distal extremity bearing the two-jointed palpus and the lacinia. Each maxilla bears a number of setæ, one large and two small ones occurring on outer face, a large one at outer and one at inner angle of base of palpus, and two small ones and one large one caudad of these. The lacinia is a brushlike organ bearing a fringe of stout bristles. Maxillary palpi (fig. 3, *c*) two-jointed; first joint slightly obconical, about as thick as long, bearing several setæ on the outer face; the second joint is a slightly truncated cone, and much smaller than the first joint, and bears a number of minute setæ at the apex.

The *labium* (fig. 3, *c*) is a very simple organ inserted between bases of maxillæ, fleshy, rectangular; distal extremity sharply rounded and fringed with minute setæ, with two larger setæ at tip; four setæ forming a semicircle near center, the two in the center much the largest; a large seta at inner angle of base of each palpus. Labial palpi (fig. 3, *c*) very minute, two-jointed; first joint cylindrical; second joint almost cylindrical but much smaller than the first and slightly rounded at tip, bearing several minute setæ.

Prothorax as large as the two following segments combined; viewed from side triangular in form; not wrinkled or folded but finely striate; dorsally the posterior margin extends back for a considerable distance into the mesothorax. The mesothorax and metathorax lie at quite an angle with the abdominal segments; posterior margin of dorsum of mesothorax extending back to center of metathorax. Metathorax about same width as mesothorax, except on dorsum, where it is somewhat narrower.

Legs fleshy, cone-shaped, four-jointed; first joint very large and more like a projection of the thorax than a joint of the leg; second joint obconical, very short, and very much smaller than the first; third joint cylindrical, short, and very small; fourth joint the smallest of all, obconical, rounded at apex, and bearing three spines at tip; a whorl of spines at each joint on outer face; segments very imperfectly defined in most cases.

Abdomen composed of nine segments, all of which are broader than the mesothorax or metathorax. First six segments bearing on their dorsal surface two round, fleshy, somewhat retractile elevations or tubercles (M. Perris, in his Larves des Coléoptères, calls them "ampoule ambulatoire.") These tubercles are almost circular in form and the apex is crumpled and folded and bears several small setæ. Dorsum of the seventh segment with a slight transverse ridge bearing a number of recurved bristles; eighth segment bearing a number of bristles, which are more numerous near posterior margin, all directed backward. First eight segments with a large fold extending their full length on each lateral face, most prominent near center of segments, at which points there are a number of bristles directed slightly to the rear. Ninth segment somewhat cone-shaped, densely covered with stout bristles, ending posteriorly in a two-pointed, chitinous projection; just below this, dorsally, are two chitinous spurs or tubercles.

Stigmata: Nine pairs of stigmata, one pair in mesothoracic region just above and slightly in front of insertion of legs and a pair to each of the first eight abdominal segments, very near the anterior margin and just above the lateral fold. They are circular in form, the thoracic being slightly the larger.

THE PUPA.

(Fig. 4.)

From the lateral aspect: Length 5 mm., diameter in thoracic region 1.125 mm. Pale cream color, somewhat acuminate-ovate, broadly rounded at head and thorax. Prothorax, from the lateral view, triangular, the dorsal surface being the base of the triangle, which is very broad and convex. Antenna passing upward at side of eye, between margin of prothorax and front femora, thence to dorsum, curving backward over base of wings. Wing-pads long and narrow, covering posterior legs, with the exception of the last three tarsal joints; front wings nearly covering hind ones.

From the ventral aspect (fig. 4): The front of head is in almost direct line with the body; mandibles small and not closed; palpi widely separated and extending beyond front tibiæ. Femora of first pair of legs directed dorsally, tibiæ resting on middle femora; first tarsal joints resting under tip of palpus; tarsal joints then extending caudad, almost parallel, except last two joints, which slightly diverge. Femora of second pair of legs parallel to femora of first pair, second tibiæ, however, forming a greater angle with their femora than tibiæ of first pair of legs; second femora and tibiæ resting upon wings for a part of their length; tarsal joints gradually converging until the last two, which nearly touch between wing pads. Third pair of legs covered by wing pads, with exception of last two joints and a part of third; last two parallel, touching, and extending to middle of sixth abdominal segment.

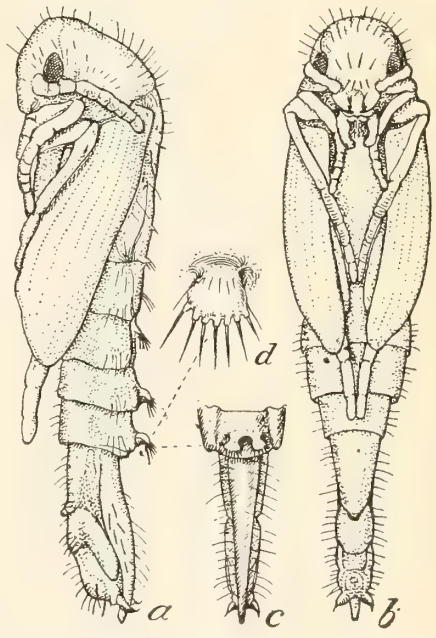

FIG. 4.—The timothy stem-borer: *a*, Pupa, lateral view; *b*, ventral view of same; *c*, ninth segment of same; *d*, setigerous tubercle of sixth segment. *a*, *b*, *c*, Greatly enlarged; *d*, more enlarged. (Original.)

Dorsal surface of the first six abdominal segments almost flat, and in the third, fourth, fifth, and sixth segments the surface produced laterally into a fleshy fold projecting over side of abdomen, the anterior margin of which is rounded and the posterior square, giving the abdomen a notched appearance; in center of each projection laterally is a group of recurved bristles.

Seventh abdominal segment (fig. 4), from a lateral view, cylindrical anteriorly; posteriorly the dorsal surface is drawn out into a long cone-shaped projection, the tip of which extends beyond the last abdominal segment, resting between its two chitinous spurs; ventral surface extending backward into a fleshy fold or lip, beyond insertion of following segment.

Eighth segment (fig. 4) somewhat cylindrical anteriorly, telescoping into seventh; dorsal surface extending backward into a large fleshy projection or lip, almost filling space between cone-shaped projection of preceding segment and Y-like chitinous projection of following segment; a deep lateral notch or incision, but ventral projection much shorter than dorsal.

Ninth segment (fig. 4) smallest, telescoping into eighth, and extending posteriorly into a Y-like projection, the tips of which, inclining forward, are amber-colored, chitinous, and spinelike.

Setæ: Numerous setæ on ventral surface of abdomen, on head, and on prothorax. First abdominal segments bearing a few setæ on dorsal surface; there is a small transverse ridge on dorsum of second segment, bearing a row of setæ; following four segments

bearing each two recurved, fan-shaped, fleshy elevations or tubercles, increasing in size with each successive segment (fig. 4, *d*); each elevation simple and bearing a fringe of bristles directed to the rear.

Last three segments bearing a number of bristles; cone-shaped projection of seventh rather thickly studded and last segment densely covered with stout bristles, all directed to the rear.

THE ADULT.

(Fig. 1.)

The description by Le Conte is as follows:

Hind tibia with two oblique ridges on the outer face; ridges parallel, the anterior one extending almost across the outer face of the tibia; first joint of the hind tarsi with three, second with two oblique ridges; elytra ferruginous, with the suture and margin blackish; ferruginous, black limb of the elytra very narrow; abdomen, and sometimes the hind coxæ and pectus, blackish. 9–11.

LIFE HISTORY AND HABITS.

THE EGG.

Females have never been observed in the act of oviposition and the period of incubation of the eggs has never been determined. The latter would be rather difficult to obtain, as eggs that are deposited in living plant tissue rarely hatch after they have been exposed to the air.

As stated above, the egg is usually deposited at and slightly below the center of the first or second joint from the top, within the plant tissues.

The number of eggs that one individual is capable of depositing has not been ascertained. Upon dissection females have never been found to contain more than four fully developed eggs and several immature ones, but they probably deposit a much greater number than this.

THE LARVA.

Upon hatching, the young larva apparently destroys the tissue immediately surrounding it, thus forming a minute cell or cavity. It then eats its way into the center of the stem and starts downward, tunneling the joints as it reaches them, and at harvest time the earlier ones are below the fourth joint, where they will be out of danger of the mower. By fall they have reached a point just above the bulb.

THE MOVEMENTS OF THE LARVA IN THE STEM.

The manner in which the larva propels itself up and down the stem is very interesting. It can ascend or descend the stem, forward or backward, apparently with equal facility. The maxillæ, which extend beyond the mandibles, the true legs, the dorsal tubercles or feet, and the anal segment all play a part in its movements. In going forward the abdomen is advanced by means of the dorsal tubercles, which act

as feet; the body is then braced by fixing the spines of the anal segment against the opposite wall of the stem; the maxillæ and true feet then advance the thorax and head. By executing these movements almost simultaneously the larvæ can move quite rapidly. In going backward the movements are reversed. The dorsal feet or tubercles and the anal spines enable the larva to support itself in the stem.

THE MOVEMENTS OF THE LARVA OUTSIDE THE STEM.

Naturally enough, as the larva seems peculiarly adapted for movement in a small hollow stem, when it is placed on a flat surface it appears wholly at a loss how to proceed. It arches its body and turns on its side, going through the same movements as though it were in a stem, but it moves very slowly. It then turns on its back and tries to walk on its dorsal feet. By bringing all of its knowledge of the different ways of walking to bear on the problem, it moves slowly, in a drunken way, to a protecting object, if any be near.

THE PUPA.

When ready to pupate, the larva (Plate I, *a*) reverses its position in the stem and ascends to a point anywhere between the first joint from the root and the first or second joint from the top, depending upon whether the timothy has been cut or not. Plate I, *b*, shows a larva ready to pupate, just below the second joint from the root. It probably locates most often just above the first or second joint from the root. It then seals up the stem above and below with detritus, making a cell of from 1 to 2 inches in length. It will reseal a stem if interfered with, but if its burrow be molested many times it will live for weeks and not pupate, finally dying.

After inclosing itself within this cell the larva becomes sluggish, contracts slightly, and thickens perceptibly in the thoracic region. It soon casts its larval skin and becomes a fully developed pupa. In Plate I, *c*, is seen a pupa in its cell just above the second joint from the root. After pupation it is a pale cream color, gradually changing to a brownish tint.

THE MOVEMENTS OF THE PUPA IN THE STEM.

The movements of the pupa in ascending and descending the stem are fully as complicated and interesting as in the case of the larva. In moving up the stem, the spurs of the last segment are planted firmly in the wall; the body is then bowed ventrally and the spines of the dorsal tubercles are brought forward and fixed in the wall; then by quickly releasing the anal spines, with the long pointed pygidium of the eighth segment, they and the dorsal tubercles act as levers and thus propel it up the stem. By executing these evolutions quickly they can move with considerable rapidity.

They can, apparently, descend with equal rapidity. By releasing the anal and dorsal spines they are lowered by gravity. If the stem be placed in a horizontal position, the pupa makes slow progress backward. The organs of locomotion are apparently not so well fitted for moving backward on a horizontal plane.

THE MOVEMENTS OF THE PUPA OUTSIDE THE STEM.

When removed from the stem and placed upon a flat surface, the pupa moves as uncertainly as the larva in the same position. It wriggles constantly, trying in vain to fix its "climbers" into something firm, whereby it can gain leverage and propel itself forward. It will fix the anal spines into the surface upon which it rests, but as there is no surface opposite and near it moves very slowly and uncertainly.

THE ADULT.

When ready to issue, the pupa is quite brown. The thin pupal envelope is ruptured along the dorsum of the thoracic region and the insect gradually forces its way out, after which it gnaws an irregular opening at some point in the stem and emerges.

The adult beetles are about 5 mm. in length, of a brownish color, and have pointed abdomens. From the lateral aspect they are somewhat crescent shaped. They are abroad from the latter part of May to the latter part of June, depending upon temperature conditions in early spring.

There is but one brood or generation during the year.

LIFE CYCLE.

LENGTH OF THE SEVERAL STAGES.

The larval stage covers a period of about 11 months. Nothing could be learned about the number of molts, as the larvæ will not develop if their galleries are disturbed.

The pupal stage varies from 11 to 16 days, depending, apparently, upon the temperature.

The adult beetles will live from 5 to 6 days in confinement, but they will probably survive a much longer period in the open.

HIBERNATION.

The insect hibernates in the larval stage. About the time freezing begins in the fall the larvæ are down to the bulb or crown of the root, where they are well protected from cold. They are nearly full grown by this time. Whenever a few warm days come, they apparently start feeding again. In the spring they burrow down into the juicy bulb, where they continue feeding until they become full grown.

THE TIMOTHY STEM-BORER (MORDELLISTENA USTULATA): LARVÆ AND PUPA IN STEMS.

PARASITIC ENEMIES.

This insect is apparently a very attractive host. Three species of parasitic Hymenoptera have been reared from it, all of them new, representing three genera—two braconids and one a chalcidid. Messrs. H. L. Viereck[a] and J. C. Crawford[b] have kindly described these parasites, giving them the following names: *Heterospilus mordellistenæ* Vier., *Schizoprymnus phillipsi* Vier., and *Merisus mordellistenæ* Crawf. The descriptions appear elsewhere over the names of their respective authors.

In May of this year, *Mordellistena ustulata* was found to be very abundant at Wilmington, Ohio, in timothy; material was collected and sent in to the laboratory at La Fayette, Ind., for rearing. Two species of parasites were reared from it, *Heterospilus mordellistenæ* and *Merisus mordellistenæ*. *Schizoprymnus phillipsi* and *Heterospilus mordellistenæ* were reared from material collected at Richmond, Ind., in 1906 and 1908, respectively. The latter species and *Merisus mordellistenæ* were reared at La Fayette, Ind., in 1910.

It is very probable that the parasitic enemies keep the beetles pretty well in check and that this accounts for the appearance of the beetles in small numbers only in any given locality.

REMEDIAL MEASURES.

As this insect has never appeared in destructive abundance, so far as known, there has been no occasion to devise means of combating it. If a serious outbreak should occur, however, a short crop rotation should be adopted, allowing a field to remain in timothy sod not more than two or three years, thus preventing this stem-borer from becoming well established. The borders of the fields and waste places should be mowed frequently during the months of June and July. If this is done, the larvæ will not be able to reach maturity.

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[a] Proceedings of the U. S. National Museum, vol. 39, pp. 401–408, 1911.

[b] Proceedings of the Entomological Society of Washington, vol. 12, no. 3, p. 145, 1910.

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U. S. D. A., B. E. Bul. 95, Part II. C. F. I. I., April 22, 1911.

PAPERS ON CEREAL AND FORAGE INSECTS.

THE MAIZE BILLBUG.

(*Sphenophorus maidis* Chittn.)

By E. O. G. Kelly,
Entomological Assistant.

INTRODUCTION.

There are several species of the genus Sphenophorus that have been reported as being enemies to young corn in early spring. Heretofore these reports have always been made in connection with fields of grass, timothy sod, or lands recently reclaimed by drainage, and the depredations were on the first cultivated crop following these conditions.

Dr. S. A. Forbes [a] records eight species of Sphenophorus the adults of which are known to attack young corn. Dr. C. V. Riley, in the report of the Commissioner of Agriculture for 1881 and 1882, records Dr. L. O. Howard's observations on the habits and natural history of *S. robustus* and gives a description of the imago, larva, and pupa, Dr. Howard having found and reared these from specimens taken from young corn plants at Columbia, S. C. Dr. F. H. Chittenden, however, in a paper entitled "On the species of Sphenophorus related to *pertinax* Oliv., with descriptions of other forms," [b] with reference to *S. robustus*, says:

> This species ranges from Indiana and Michigan through Wisconsin, Minnesota, and western Kansas to California. It is a northern form, not occurring in the East. Nothing appears to be known of its habits, reference to *robustus* and its injuries to corn being due to a distinct species, my *S. maidis*.

Dr. Chittenden had before him, while describing *S. maidis*, among numerous other specimens, the one specimen from Columbia, S. C., reared by Dr. Howard. According to his statement *maidis* is a valid species and quite distinct from *S. robustus*.

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[a] Twenty-third Report of the State Entomologist of Illinois, 1905.

[b] Proc. Ent. Soc. Wash., vol. 7, p. 57, 1905.

Dr. Chittenden informs the writer that since 1895 complaints have been made every few years in localities in Kansas, South Carolina, Georgia, and Alabama of injuries to corn by what he believes to be this species of billbug. The species has been quite generally confused with *Sphenophorus pertinax* Oliv. and *S. robustus* Horn, by both of which names it has been mentioned in economic literature, more especially by the latter. It is, however, quite distinct from either, in fact, different from any billbug known to inhabit the United States, and has only recently been described as new to science, although Dr. Chittenden states that it is by no means new as an agricultural foe.

The observations on the maize billbug (*Sphenophorus maidis* Chttn.) given herein were made by the writer between June and December, 1910.

HISTORY OF THE SPECIES.

The history of this species, the writer is informed by Dr. Chittenden, is, in brief, that it first attracted attention in Alabama as early as in 1854; again in the same State in 1880; in South Carolina in 1881; in Kansas in 1895; in 1901 it again did injury in Kansas, and in 1903 in Georgia. The fact that the insect is injurious to corn in both of the active stages, larva and beetle, indicates that it is a more or less permanent pest, whereas several of our equally common corn billbugs will eventually disappear with the reclamation by draining and the cultivation of the soil and the consequent destruction of their breeding places.

In the opinion of Dr. Chittenden, this is the species described and figured by Townend Glover in 1855[a] as the "billbug" or 'corn borer (Sphenophorus ?)," since both description and figure do not apply to any other billbug known to breed in corn. Glover describes the beetle as from four-tenths to six-tenths of an inch in length, and of a reddish-brown or reddish-black color, and the rostrum or snout in the figure can not belong to any other Sphenophorus. None of the specimens which served as models of the drawing remains in the Government collections. The billbug was reported as very destructive to corn in many parts of the South and Southwest, more particularly along the Pedee River. Injuries were reported by Senator Evans, Gen. Fitzpatrick, and Col. Pitchlynn. Senator Evans's report is as follows:

> The perfect insect eats into the stalk of the corn, either below or just at the surface of the ground, where it deposits its egg. After changing into a grub, the insect remains in the stalk, devouring the substance, until it transforms into the pupa state, which occurs in the same cavity in the stalk occupied by the grub. It makes its appearance the following spring in the perfect state, again to deposit its eggs at the foot of the young corn plants. These

[a] Agricultural Report of the Patent Office for 1854 (1855), p. 67, pl. 4.

insects destroy the main stem, or shoots, thus causing suckers to spring up, which usually produce no grain, or, if any, of very inferior quality to that of the general yield. Swamp lands or low grounds are the places most generally attacked.

Senator Evans thus is, according to Chittenden, to be credited with the discovery that the larva develops in the stalk of corn below the ground, and not in decaying wood, as contended by Messrs. Walsh and Riley in later years. The insect was said to be very destructive in Alabama, from which State the specimens chosen for illustration doubtless came, and on the Red River in Arkansas. With little doubt it was the same insect operating in Arkansas, as it is now known that this species ranges between South Carolina and Missouri.

This insect was observed in the spring of 1881 by Dr. L. O. Howard, at that time assistant to Dr. C. V. Riley, Entomologist of the Department of Agriculture. Dr. Howard was at once sent to Columbia, S. C., to investigate the injury being done to corn by "billbugs," and the following account of these investigations is taken from the report of his observations:[a]

The species found near Columbia, S. C., is *S. robustus* [now *S. maidis*]. In the plantations along the bottom lands of the Congaree River much damage is done by the adult beetle every year, and the corn not infrequently has to be replanted several times, as the earlier plantings are destroyed. The beetles are first noticed in the spring after the corn is well up. Stationing themselves at the base of the stalk, and also burrowing under the surface of the earth slightly, they pierce the stalk and kill many plants outright, others living to grow up stunted and dwarfed.

With *S. sculptilis* [*zeæ*], in spite of the damage it has done, the earlier stages remain unknown, Walsh surmising that the larva breeds on rotten wood, so situated that it is continually washed by water. With this statement in my mind I was prepared to doubt the statement of Mr. W. P. Spigener, of Columbia, who informed me that the "grub form of the billbug" was to be found in the corn, but a couple of hours in the field convinced me that he was right, my previous idea having been that he had mistaken the larva of *Chilo saccharalis* for the weevil grub. I searched a field on Mr. Spigener's plantation, which was said to be the worst point in the whole neighborhood for bugs, for some time before finding a trace of the beetle in any stage, but at last, in a deformed stalk, I found in a large burrow, about at the surface of the ground, a full-grown larva. After I had learned to recognize the peculiar appearance of the infested stalks I was enabled to collect the larvæ quite rapidly.

They were present at this date (Aug. 20) in all stages of larval development, but far more abundantly as full-grown larvæ. A few were preserved in alcohol and the remainder forwarded alive to the department, but all died on the way. Two pupæ were found at the same time; one was preserved in alcohol and the other forwarded to the department. The beetle issued on the way, and from this specimen we have been able to determine the species. From an examination of a large number of injured stalks it seems evident that the egg is laid in the

[a] Report of the Entomologist, Department of Agriculture, for 1881 and 1882, pp. 139–140.

stalk just at the surface of the ground, preferably and occasionally a little below. The young larvæ, hatching, work usually downward, and may be found at almost any age in that part of the stalk from which the roots are given out. A few specimens were found which had worked upward for a few inches into the first section of the stalk above ground, but these were all very large individuals, and I conclude that the larva only bores into the stalk proper after having consumed all available pith below ground.

The pupæ were both found in cavities opposite the first suckers, surrounded by excrement compactly pressed, so as to form a sort of cell.

Wherever the larva had reached its full size, the pith of the stalk was found completely eaten out for at least 5 inches. Below ground even the hard external portions of the stalk were eaten through, and in one instance everything except the rootlets had disappeared and the stalk had fallen to the ground.

In a great majority of instances but a single larva was found in a stalk, but a few cases were found where two larvæ were at work. In no case had an ear filled on a stalk bored by this larva. The stalk was often stunted and twisted, and the lower leaves were invariably brown and withered.

In one field, which had been completely under water for six days in January, the beetles were apparently as healthy as in fields which had remained above water.

INJURIES SINCE 1895.

The records of reports of injury which follow, received by Dr. Chittenden during the past decade, substantiate the observations of Dr. Howard made in 1881, and add as well to our knowledge of the life economy of the species.

In 1895 this billbug was destructive in three localities in Kansas, complaints all being made during the first week of May. At Cedar Vale immense damage was done, the insect "taking whole fields of corn, hill by hill." Similar injury was observed at Dexter and Leon, these reports having been made by Mr. Hugo Kahl in a letter dated July 27, 1898.

The following year Prof. F. S. Earle reported, June 6, injury by this species at Wetumpka, Ala., on the Coosa River, where there was great complaint of it as a destructive enemy of corn, especially on low-lying bottom lands. The insect was well known there as a billbug, and was not found on hilly land. It worked below ground, and when the stalks were not killed outright they put out an immense number of suckers. The beetles were most destructive to early plantings, corn planted after the middle of May being usually little injured.

In 1901 Mr. J. E. Williams, Augusta, Butler County, Kans., wrote, August 28, of injury to corn. Attack commenced as soon as the corn came through the ground, and the billbugs ate and dug down to the kernel and devoured that. In larger corn they bored into the stalk and wintered over in the old stalks, usually below ground. Whole fields were destroyed, the beetles remaining to continue their work on second plantings. The insect was known locally as the "elephant bug." September 6 Mr. Williams sent larvæ and adults and their

work in the root-stalks of corn. He had observed that the eggs were deposited in the stalks, and that these serve for the winter quarters of the adults; that the beetles began work when the corn was about 4 or 5 inches high by inserting their beaks in the young stalks just above ground. By taking hold of the center of the corn and pulling it it came out, as it was nearly severed as from cutworm attack. Stalks that had been preyed upon by the billbug did not yield any amount of seed. No injury was observed to crops other than corn. Injury was only in lowlands, and the principal damage was accomplished before the woody outer shell of the stalk was formed. The beetles were active chiefly after dark, when they traveled, though slowly, from one place to another. They burrowed in the ground during the day. They were described as "cleaning up everything as they go, rendering the crop entirely worthless." September 17 another sending of larvæ, pupæ, and imagos were received from the same source. Out of 100 stalks examined by our correspondent only 10 were free from the ravages of this billbug. At this date of writing the beetles were deserting the corn.

In 1903 a report was received of injury by what was with little doubt this species at Griffin, Ga., although no specimens were received, as in all preceding instances cited.

DISTRIBUTION.

This insect has been reported, according to Chittenden,[a] from Augusta, Kans. (E. L. Williams); Riley County, Kans. (P. J. Parrott); Florence, Kans.; Dadeville, Ala. (S. M. Robertson); Wetumpka, Ala. (F. S. Earle); Columbia, S. C. (L. O. Howard); Ballentine, S. C. (J. Duncan); Texas (Ulke, 1 ex.); Michigan (Knaus). It has also been reported from Texas (T. D. Urbahns), and the writer found it at several points in Oklahoma and Kansas. Owing to the fact that representatives of the species have been taken in such widely separated localities, it is very probable that it occurs over the entire territory between South Carolina and Texas and northward to Kansas and Missouri.

FOOD PLANTS.

The adults attack young corn plants and probably some of the coarser grasses. Dr. Howard, and later the writer, found both adults and larvæ feeding on young corn. Mr. Urbahns found adults at base of swamp grass (*Tripsacum dactyloides*) in considerable numbers, and probably larvæ and pupæ of the species in this same grass (fig. 8). Mr. Urbahns found several Sphenophorus larvæ

[a] Proc. Ent. Soc. Wash., vol 7, No. 1, pp. 59–61, 1905.

in burrows in this swamp grass and two pupæ, but failed to rear them. Dr. Chittenden determined these pupæ as having adult characters of *S. maidis*.

DESCRIPTION AND LIFE HISTORY.

THE EGG.

(Fig. 5.)

Eggs were found by the writer in southern Kansas during June in punctures made especially for them (fig. 7, *b*) in young corn plants. These egg punctures, which the female makes with her beak, are scarcely visible on the outer surface of the stalk, being only a slit in the sheath of the plant, through which the beak, and later the ovipositor, are thrust, the sheath closing readily when the egg is deposited and the ovipositor withdrawn. The eggs are about 3 mm. long and 1 mm. thick, creamy white in color, elongate, and somewhat kidney-shaped, with obtusely rounded ends, being slightly more rounded at one end than at the other; the surface is smooth, without punctures.

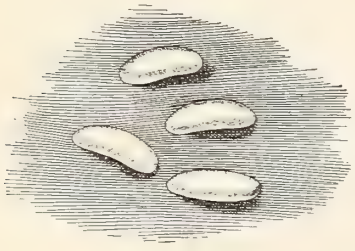

FIG. 5.—The maize billbug (*Sphenophorus maidis*): Eggs. Enlarged three times. (Original.)

In the latitude of southern Kansas eggs were laid in the corn plants during the month of June, where they hatched in from 7 to 12 days, the young, footless grub thus finding itself surrounded with the choicest food.

THE LARVA.

(Fig. 6.)

The newly hatched larvæ are white, with a light-brown head, the head changing to darker brown within a few days. The color remains white in the full-grown larvæ, with the head chestnut brown. The length of full-grown living larvæ ranges from 15 to 20 mm. and the width from 4 to 5 mm.

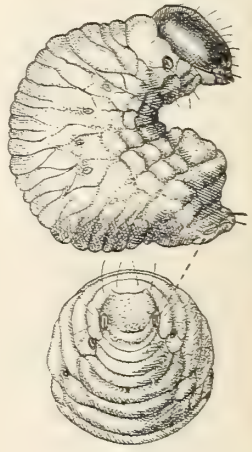

FIG. 6.—The maize billbug: Larva. Twice natural size. (Original.)

The following description of the full-grown larva was made by Mr. E. A. Schwarz under the name of *S. robustus*, from the few alcoholic specimens collected by Dr. Howard at Columbia, S. C.:[a]

Length 12 mm.; color dingy white; head chestnut brown, with four vittæ of paler color, two upon the occiput, converging toward the base, and one along each lateral margin; trophi very dark, clypeus paler; body fusiform, strongly

[a] Report of the Entomologist, Department of Agriculture, for 1881 and 1882, p. 141.

curved, swelling ventrally from the third abdominal joint posteriorly, slightly recurved and rounded at anal extremity. Head large, oblong, obtusely angulate at base, sinuately narrowed anteriorly; frontal margin with a shallow emargination between the mandibles; upper surface with a median channel, the occipital portion deeply incised, with raised edges, continuing as a shallow impressed line to the middle of the front; on either side an engraved line, commencing upon the vertex, becoming deeper after crossing the branches of the Y suture, and terminating at the frontal margin in a bristle-bearing depression; sides and vertex with several long bristles arising in depressions; antennæ rudimentary, occupying minute pits on the frontal margin at the middle of the base of mandibles; ocelli a single pair, visible only as translucent spots upon the anterior face of the thickened frontal margin, outside of and closely contiguous to the antennæ from which they are separated by the branches of the Y suture, a few pigment cells obscurely visible beneath the surface; clypeus free, transverse, trapezoidal, with faint impressions along the base and at the sides; labrum small, elliptical, bearing spines and bristles, a furrow each side of the middle, forming three ridges, so that the organ, when deflected, appears three-lobed; mandibles stout, triangular, unarmed, with an obsolete longitudinal furrow on the outer face; maxillæ stout, cardinal piece transverse, basal piece elongate, bearing a palpus of two short joints, and a small rounded lobe, furnished at tip with a brush of spiny hairs, the lobe concealed by the labium; labium consisting of a large triangular mentum, excavate beneath, and a hastate palpiger, with a deep median channel; labial palpi divergent, separated by the ligula, of two joints subequal in length; ligula represented by a prominent rounded lobe, densely ciliate on the under surface. Thoracic joints separated above by transverse folds; the first wider, covered above by a transverse, thinly chitinous plate; the two following similar to the abdominal joints; abdominal joints forming on the dorsum narrow transverse folds, separated by two wider folds, the anterior fold attaining the ventral surface, the second fold confined to the dorsum, eighth and ninth abdominal joints longer, excavate above, without dorsal folds; beneath, the first three joints contracted, the succeeding joints enlarged, the terminal joint broadly rounded, with anal opening upon a fold at its base; sides of each joint presenting numerous longitudinal folds; stigmata very large, nine pairs; the first on the anterior margin of the prothorax, low down upon the sides; the remainder upon the sides of the first eight abdominal joints, above the lateral prominences, beginning upon the first joint at the middle of the side and gradually rising to a dorsal position upon the eighth joint; thoracic and last abdominal pairs large, oval; the intermediate pairs smaller, elliptical; all with chitinous margins of dark-brown color. The noticeable features of this larva are its cephalic vittæ, and conspicuous spiracles.

Upon issuing from the eggshell the young larvæ are about 5 mm. long and 2 mm. thick. They at once begin feeding on the tissues of the young corn at the bottom of the egg puncture (fig. 7, *b*), directing their burrowing inward and downward into the taproot. When they finish eating the tender parts of the taproot they direct their feeding upward, continuing until full grown, allowing the lower portion of the burrow to catch the frass and excrement (fig. 7, *a*). This burrowing of the taproot of the young growing corn plant is disastrous to the root system (Pl. I, figs. 1, 2); the roots, first dying at the tips, soon become of little use to the plant, allowing it to die or to become more or less dwarfed (Pl. II). The corn plants shown

in Plate I were collected in Kansas and forwarded, in moist paper, to Washington, D. C., and photographed by the official photographer, Mr. L. S. Williams, and show the injuries more clearly, while Plate II, photographed in the field, illustrates the effect on the standing corn. Small plants, even those of less than one-half inch in diameter, are often recipients of eggs from which the larvæ, on hatching, burrow into the heart of the plant and cut off the growing bud, thus killing the top; they then direct the burrowing downward only to

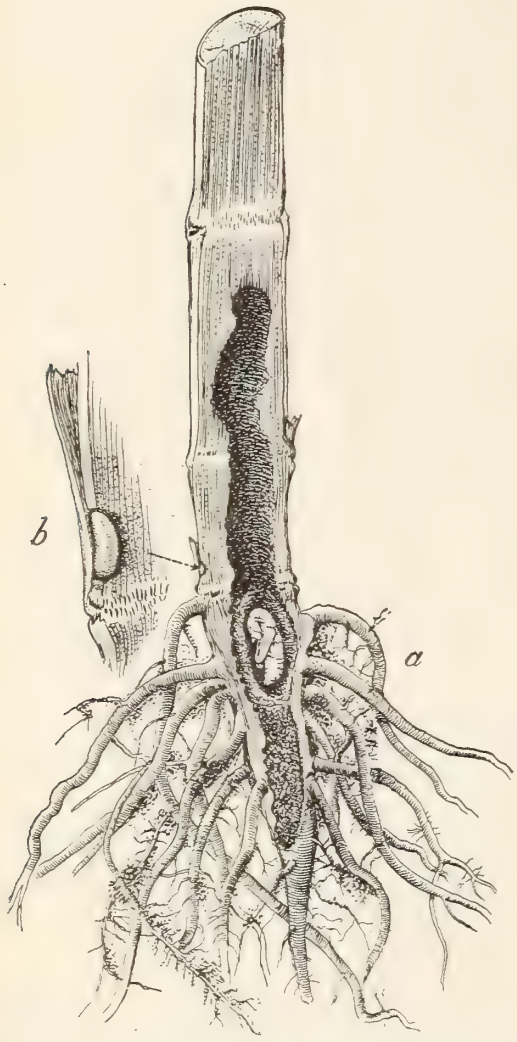

FIG. 7.—Corn plant showing result of attack by the maize billbug: *a*, Larval burrow containing pupa in natural position; *b*, egg puncture containing eggs. *a*, Reduced two-thirds; *b*, enlarged. (Original.)

FIG. 8.—Swamp grass (*Tripsacum dactyloides*), attacked by the maize billbug. Reduced two-thirds. (Original.)

devour the stub, leaving themselves without food, and, being footless grubs, they of course perish. Plants of more than one-half inch diameter which become infested with larvæ make very poor growth, being very slender, rarely reaching a height of more than 2 or 3 feet before tasseling (Pl. II), and do not produce shoots or ears. Those that do not become infested until they are half grown may produce small ears. Each larva inhabits only the one burrow, and if, owing to any mishap, it becomes dislodged from it, it is powerless to reestablish itself. The larva does not become dislodged from the burrow

FIG. 1.—CORN PLANT INJURED BY THE ADULT OF THE MAIZE BILLBUG (SPHENOPHORUS MAIDIS), AFTERWARD ATTACKED BY THE LARVA. FIG. 2.—CORN PLANT SHOWING ON STALK THE EFFECTS OF FEEDING BY ADULT MAIZE BILLBUGS, AND EFFECTS ON ROOTS OF FEEDING BY THE LARVÆ. FIG. 3.—CORN PLANT, MUCH DISTORTED, SHOWING SUCKERS; FINAL EFFECTS OF FEEDING OF ADULT MAIZE BILLBUGS.

All figures about natural size. (Original.)

CORN PLANTS SHOWING EFFECTS OF FEEDING OF MAIZE BILLBUG IN THE FIELD.

Plant at left not attacked, the two at right attacked by larvæ. Reduced. (Original.)

of its own accord. Sometimes there are three or four larvæ in the same plant, their burrows often running into each other, but this does not appear to discommode them in the least, as they can, and usually do, all mature. In badly infested fields two larvæ are quite often in the same plant, although one is the usual number and is sufficient to ruin the plant. The larvæ are easily managed in the laboratory; upon issuing from the eggshell they can be readily handled with a soft camel's-hair brush and placed inside a section of a cornstalk, where they will feed as readily as upon the growing plant. As soon as the section of plant is fairly eaten, and before decay sets in, the larvæ must be removed to fresh sections; keeping them thus supplied with fresh food they can be reared to maturity.

The length of the larval life ranges from 40 to 50 days, as indicated by laboratory observations and checked by collections in the field. They begin maturing and pupating by the 1st of August, pupation reaching the maximum by the 20th, and with the exception of a few stragglers all are mature and changed to pupæ by the 1st of September.

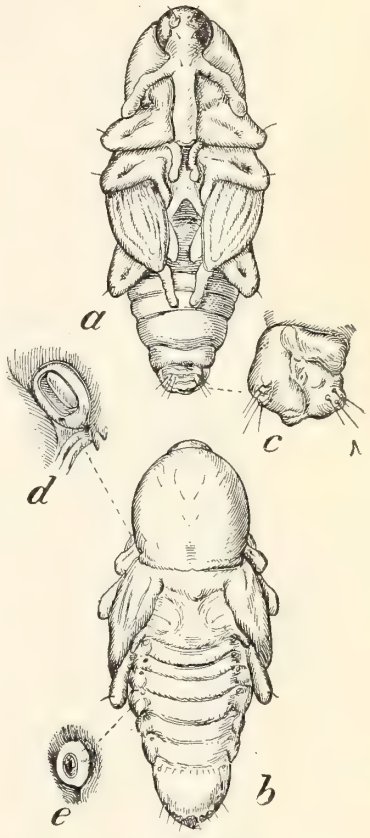

FIG. 9—The maize billbug; Pupa: *a*, ventral view; *b*, dorsal, view; *c*, anal segment; *d*, thoracic spiracle; *e*, abdominal spiracle. *a*, *b*, Twice natural size; *c*, *d*, *e*, greatly enlarged. (Original.)

THE PUPA.

(Fig. 9.)

The larvæ, on finishing their growth, descend to the lower part of the burrow, to the crown of the taproot, cutting the pith of the cornstalk into fine shreds with which they construct a cell where they inclose themselves for pupation.

The newly issued pupæ are white, becoming darker after the fourth or fifth day, and continue to darken until just before the adults issue. The adults are reddish black in color. The length of living pupæ ranges from 16 to 20 mm.

The following description of the pupa was made by Mr. E. A. Schwarz, of the Bureau of Entomology, under the name of *S. robustus*, from the single individual collected by Dr. Howard at Columbia, S. C.:[a]

Average length, 17 millimeters. Stout, rostrum reaching between first pair of tarsi. Antennæ but slightly elbowed and reaching not quite to bend of

[a] Loc. cit., p. 142.

anterior femora and tibiæ. Eyes scarcely discernible. Face with three pairs of shallow tubercles, the basal pair the largest, and each giving rise to a stiff, brown hair. Other minute piliferous tubercles, especially near the posterior dorsal border of the abdominal joints, being very stout on the preanal joint, or pygidium, where they form two series of quadridentate ridges.

To Mr. Schwarz's description the following may be added:

Lateral view: Body oblong, thickest at middle; thorax depressed anteriorly; abdomen cylindrical, tapering from seventh segment; thoracic pair of spiracles very prominent (fig. 9, *d*), first five pairs of abdominal spiracles prominent (fig. 9, *c*), the three on the rear segments not prominent. Elytra short, curving ventrally between middle and hind legs, reaching tarsi of hind leg, covering upper half of femur of hind leg; middle leg resting on elytra.

The pupæ occur mostly during the latter part of August and first part of September and are always to be found in their cells in the larval burrows near the crown of the taproot and nearly always below the surface. The pupal period is from 10 to 12 days.

THE ADULT.

(Fig. 10.)

The adults are very large, robust, and reddish black when newly issued, changing to black when older. The original description by Chittenden[a] is given here:

Body two-fifths as wide as long, of robust appearance because of the subquadrate thorax, which is nearly as wide as the elytra; general color black or piceous, moderately shining; alutaceous deposit on unelevated surfaces inconspicuous, appearing to be normally dark rufous or piceous velvety when the extraneous argillaceous covering does not persist.

Rostrum three-fifths the length of the thorax, considerably arcuate, strongly subequally compressed, apex prolonged at the posterior angle with an acute spine, producing the appearance of greater curvature of the inner surface, base feebly protuberant, moderately dilated; anterior face of apex broadly deeply concave; surface minutely punctate, more distinctly and densely at base, base moderately deeply channeled with distinct deep interocular puncture and short impressed line.

Thorax longer than wide, fully three-fourths as long as the elytra, sides usually widest just in front of middle, anterior third suddenly and very strongly arcuate and constricted at apex, posterior two-thirds or three-fourths subparallel, or gradually narrowing to the base which is feebly bisinuate. Vittæ feebly elevated, tending toward obsolescence, moderately finely but distinctly and sparsely punctate, more coarsely and densely at the ends; median vitta extending from a fine line and rapidly widening to a point just in front of the middle where it is broadly dilated, then more abruptly narrowed, extending in a narrower line to near the base; lateral vittæ sinuous with a tendency to become confluent with the median in the apical half, generally a little wider in basal half but narrower than the median, branch wide but ill-defined; interspaces and surface at sides coarsely foveate-punctate, punctures becoming confluent, especially posteriorly at sides. Scutellum deeply broadly concave.

[a] Proc. Ent. Soc. Wash., vol. 7, No. 1, p. 59, 1905.

Elytra little wider than the thorax; striæ usually deep and well defined, distinctly closely punctate; intervals with first, third and fifth elevated, with two or more series of rows of fine punctulation; first or sutural with basal third triseriately, posterior two-thirds biseriately punctulate; third widest and most elevated, with four or five rows of fine punctulations; fifth biseriately punctulate; seventh little or not at all more elevated than the remaining intervals; intervals 2, 4, 6, 8, as also 7, more coarsely and closely uniseriately punctulate. Pygidium deeply, coarsely and rather sparsely punctate, with sparse golden yellow hairs proceeding from the punctures and forming a short tuft each side, frequently abraded.

Lower surface coarsely and rather densely punctate, scarcely less strongly at the middle than at the sides, punctures largest at the middle of the metathorax. Punctures of the metepisterna (side pieces) more or less confluent. Second, third and fourth abdominal segments nearly uniformly punctured throughout, like the legs.

♂.—First abdominal segment very concave; pygidium truncate at apex.

♀.—First ventral scarcely different; pygidium narrowed and rounded at apex.

Aside from the differently shaped pygidium and the slightly shorter and less compressed rostrum there is little difference between the sexes.

Length, 10–15 mm., width, 4.5–6.0 mm.

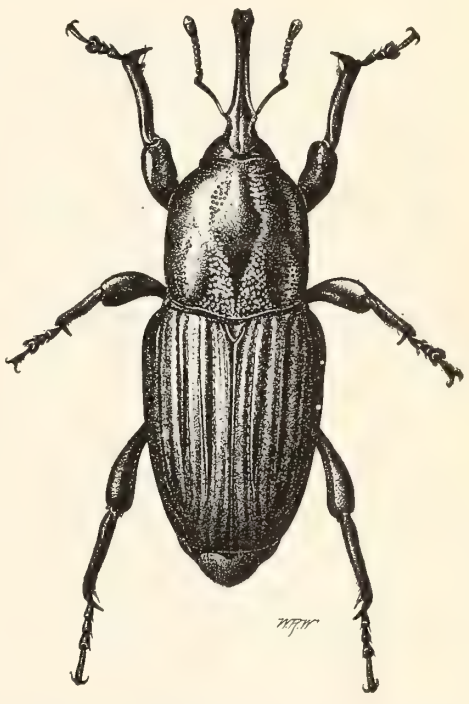

FIG. 10.—The maize billbug: Adult. Four times natural size. (Original.)

The adults begin to issue about the middle of August and continue to do so until the middle of September. Some of them leave the pupal cell, but most of them remain there for hibernation. The adults that leave the pupal cell in the late summer disappear; continued search in every situation until December failed to reveal a single individual. It is evident that they left the cornfield in which they developed, and it is very probable that they found their way to some dense, coarse grass (*T. dactyloides*), which is abundant in the locality, The adults hibernating in the pupal cells issue from them in late spring, about the time young corn is sprouting. The beetles are rarely observed on account of their quiet habits and because they are covered with mud—a condition which is more or less common among several species of this genus and is caused by a waxy exudation of the elytra, to which the soil adheres. The presence of the adults of this species in a cornfield is made evident by the withering of the top leaves of very young corn plants, the plants having been severely gouged. The adults kill the small plants outright and injure the larger ones beyond repair. After the plants grow 10 to 15 inches tall they do not kill them, but gouge out such large cavities in the stalks that they become twisted into all sorts of shapes (Pl. I,

fig. 3). The attacked plants sucker profusely, affording young, tender growth for the beetles to feed upon, even for many days after the noninfested plants have become hard. The corn plants injured by *S. maidis* resemble somewhat corn plants injured by the lesser corn stalk-borer (*Diatræa saccharalis*), and are easily distinguished from plants injured by the smaller species of Sphenophorus owing to the fact that the punctures of the smaller species are not always fatal to the plants, which, however, in unfolding their leaves, show a row or series of rows of round or oblong holes in them.

The females issuing from hibernation feed on young corn for a few days before beginning to deposit their eggs. The egg punctures are made by the female in the side of the cornstalk (fig. 7, *b*) beneath the outer sheath. These egg punctures are not injurious to the plants, being only small grooves, about 5 mm. long and 3 mm. deep, in which the eggs snugly fit.

NUMBER OF GENERATIONS.

There is only one generation a year. The eggs occur throughout June, larvæ from early June until September, pupæ from the first part of August until the last part of September, and adults from the middle of August until the first part of August of the following year.

RECORDS OF DEPREDATIONS.

The depredations of this species have probably been confused with that of other species, the first and only known record of its attack on young corn being that made by Dr. Howard, at Columbia, S. C. During the season of 1910 both adults and larvæ were numerous in cornfields in lowlands in southern Kansas and northern Oklahoma, doing serious damage in some instances. They were frequently found in uplands, but not in injurious numbers.

REMEDIAL MEASURES.

The knowledge of the hibernating habits of the insect suggests an effective remedy in the pulling up and burning of the stubble, which is also the most practical means of destroying the lesser corn stalk-borer (*Diatræa saccharalis*). The beetles remain in the taproot of the corn plants until spring, allowing the farmer abundant time to destroy them. Care must be taken, however, in pulling up the infested stalks or else they will break off above the beetle, leaving the pest in the ground. The infested stalks, having a very poor root system, are easily pulled. Spraying the young corn plants with arsenical fluids at the time the beetles are making their attack is a very laborious procedure and not very effective.

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PAPERS ON CEREAL AND FORAGE INSECTS.

CHINCH-BUG INVESTIGATIONS WEST OF THE MISSISSIPPI RIVER.

By E. O. G. Kelly, *Entomological Assistant.*
and
T. H. Parks, *Entomological Assistant.*

INTRODUCTION.

Chinch bugs have long been a pest, and, especially so in the Middle Western States. During the last two years especially, Kansas, Oklahoma, and parts of Missouri and Illinois have suffered great losses from their ravages.

Owing largely to a lack of knowledge of the habits of the chinch bug, farmers are at a loss for remedies; the tried and successful tar lines and dust barriers, crudely used by them, to prevent the bugs from entering their corn, being often applied without success.

The "white fungus" or "fungus disease" of chinch bugs (*Sporotrichum globuliferum*), as it is commonly known among farmers, has been carefully observed and the conclusion reached that under ordinary farm conditions it can not be relied upon to afford immediate protection.

This paper has been written for the purpose of giving the farmers information regarding the habits of this insect, and the most effective methods of combating it. Field observations on this pest in Kansas, Oklahoma, and Missouri were begun during the spring of 1907 and continued till March, 1911, Mr. C. N. Ainslie and Mr. Paul Hayhurst making observations in 1907, and the senior author from the spring of 1908 to July, 1911, assisted by the junior author, who also did the photographic work, during the year ending with July, 1910.

DISTRIBUTION.

The chinch bug is widely distributed over the United States as well as in parts of Canada and in Mexico. The accompanying map (fig. 11) shows its distribution west of the Mississippi River. It is especially destructive over portions of Minnesota, Iowa, Missouri, Arkansas, Texas, Oklahoma, Kansas, Nebraska, and South Dakota,

and in parts of Illinois. Prof. T. D. A. Cockerell found a few specimens of both the long-winged and the short-winged forms at Mesilla Park, N. Mex.; Messrs. E. A. Schwarz and H. S. Barber, of this bureau, found a few short-winged forms at Hot Springs, Yavapai County, Ariz.; Mr. George I. Reeves found some long-winged forms in southwestern Washington; and Mr. Albert Koebele and Dr. P. R. Uhler found a few at San Francisco and Alameda, Cal., and also in Lower California. Prof. Herbert Osborn found the short-winged form at Sault Ste. Marie, Mich., and Mr. Herbert T. Osborn found it at Wellington, Kans.

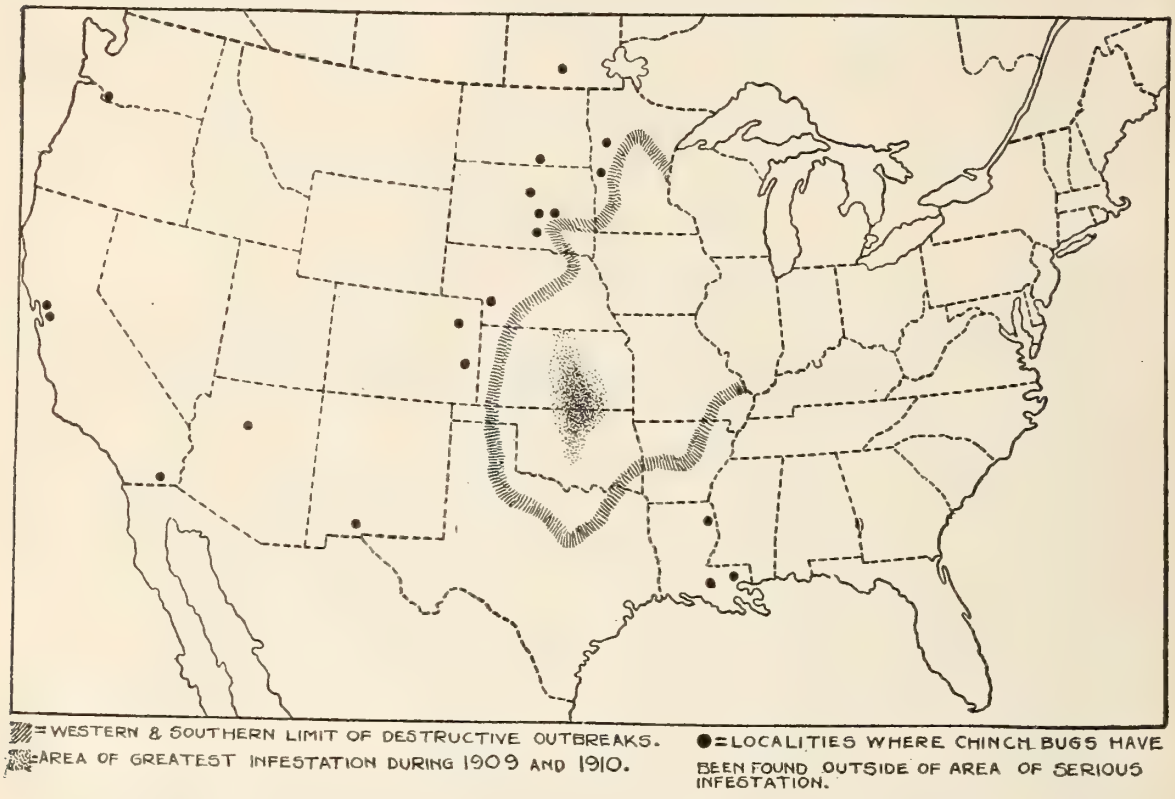
=WESTERN & SOUTHERN LIMIT OF DESTRUCTIVE OUTBREAKS.
=AREA OF GREATEST INFESTATION DURING 1909 AND 1910.
●=LOCALITIES WHERE CHINCH BUGS HAVE BEEN FOUND OUTSIDE OF AREA OF SERIOUS INFESTATION.

FIG. 11.—Map showing distribution of the chinch bug west of the Mississippi River, 1911. (Original.)

DESCRIPTION AND NUMBER OF GENERATIONS.

Full descriptions of this insect are found in Bulletin No. 69 and in Circular No. 113 of this bureau and will not be repeated here.

There are two principal generations annually in the Middle West; the spring generation and the fall, or hibernating, generation, and a partial third generation sometimes occurs in late fall to the southward.

MIGRATIONS.

The hibernating bugs (fig. 14) issue from their winter quarters as soon as the sun warms up the grasses in the spring, and fly out to green grasses and young wheat and barley, where they feed, mate, and deposit their eggs. The eggs (fig. 13 *a*, *b*) begin to hatch in late April and continue hatching until June, varying with the seasonal temperature and the latitude of the locality affected. The young bugs

FIG. 1.—CORN PLANT KILLED BY CHINCH BUG. (ORIGINAL.)

FIG. 2.—CHINCH-BUG RAVAGES IN CORNFIELD IN SOUTHERN KANSAS, 1910. (ORIGINAL.)

FIG. 3.—CORNFIELD ADJOINING WHEAT FIELD FROM WHICH CHINCH BUGS MIGRATED IN IMMENSE NUMBERS AT HARVEST TIME. (ORIGINAL.)

RAVAGES OF THE CHINCH BUG (BLISSUS LEUCOPTERUS).

hatching from these eggs constitute the spring generation (fig. 13 *c, e, f, g*) and are the ones that do such enormous damage to wheat and young corn. Some of this generation reach maturity as they are migrating from wheat to corn, but most of them reach the corn (see fig. 12) before maturing and do much damage thereto. It is because the immature bugs reach the young corn in such immense numbers and mass upon the plants that they do such widespread damage

FIG. 12.—Corn plant about 2 feet tall, infested by chinch bugs. (Original.)

(see Pl. IV), their depredations ceasing as they reach maturity. Only on rare occasions is an entire cornfield devastated, and often the depredation is brought to an abrupt standstill within a few rods of the opposite margin of the field because the bugs have reached maturity and dispersed. During July and August the insects mate, and the eggs for the second generation are deposited about the corn plants, where the young, on hatching, find an abundance of easily accessible food. Some of this generation reach maturity (see fig. 14) before the corn becomes dry, and migrate to volunteer wheat, but most of

them are forced to seek their food elsewhere. They usually find this in kafir cane fields, and among some of the grasses, where they reach maturity. From here they go to winter quarters before cold weather.

STATUS OF THE CHINCH-BUG PROBLEM IN KANSAS, MISSOURI AND OKLAHOMA.

That the seasons of 1907 to 1910 have been favorable for the development of chinch bugs in Kansas, Missouri, and Oklahoma is indicated by reports of injury to crops received during these years.

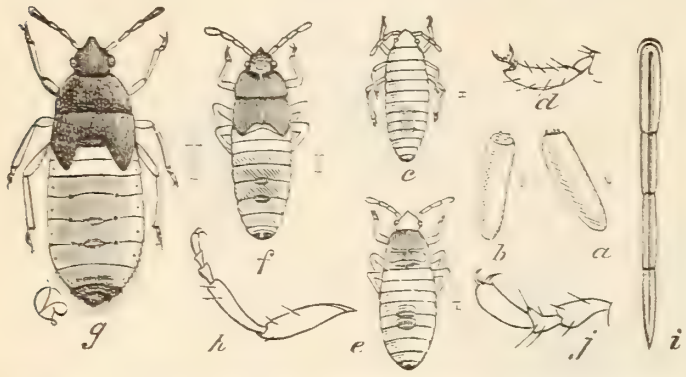

FIG. 13.—Chinch bug: *a*, *b*, Eggs; *c*, newly hatched larva, or nymph; *d*, its tarsus; *e*, larva after first molt; *f*, same after second molt; *g*, last-stage larva; the natural sizes indicated at sides; *h*, enlarged leg of perfect bug; *j*, tarsus of same, still more enlarged; *i*, proboscis or beak, enlarged. (From Riley.)

The prevalence of the pest and its depredations depend upon meteorological conditions to a great extent, as has been discovered by entomologists in the past, and this fact is clearly brought out by the observations herein recorded and made during the four seasons from 1907 to 1910, inclusive.

The bugs were very numerous in wheat fields in the early spring of 1907 and deposited numbers of eggs on the young wheat plants. Much wheat had been destroyed by the "green bug" (*Toxoptera graminum* Rond.) during the spring, and many farmers had plowed up their fields and planted them to corn; sometimes they did not use the gang plow, but planted the corn with a combination lister and planter. There were large numbers of eggs and young of chinch bugs on this more or less dead wheat that was plowed under, and apparently very few were destroyed during the operation of preparing the ground for planting the corn. As soon as the corn plants pushed through the soil they were attacked by the young chinch bugs, with the result that a large amount of young corn was ruined by them.

FIG. 14.—Chinch bug (*Blissus leucopterus*): Adult of long-winged form, much enlarged. (From Webster.)

In the fields of wheat that had not been plowed under in the spring there were also numbers of bugs, and at harvest time these found their way to other fields of young corn, where they inflicted considerable damage. The summer and fall were favorable for their development, and great numbers went into hibernation in grasses.

The spring of 1908 opened the first week of March with warm, dry weather and a deficiency of moisture which was alarming for this season of the year and which had a telling effect on young wheat. The chinch bugs flocked to the young wheat from their winter quar-

ters, and very soon their ravages were in evidence. By the middle of April the plants were turning to a red color, and the stems were black and dry from their attacks, very few plants escaping, some plants having as many as 200 bugs massed on them. Very few eggs had been deposited up to the middle of April, but from this time on until May 1 eggs were abundant.

The eggs began to hatch about the 1st of May, and in one week's time the wheat fields were swarming with tiny red bugs, much of the wheat dying from their severe attack combined with the effects of lack of moisture. However, the situation was soon rapidly changed, for rains came, and by the 1st of June there was hardly a living bug to be found, either young or adult, but there were numbers of unhatched eggs left unharmed on the plants. The wheat partially outgrew this damage and made a fair crop, while the young corn escaped injury.

Many eggs hatched after the rains ceased, and the bugs from these eggs, together with the few that survived the drenching rains of May and June, succeeded in getting to the corn, where they bred in large numbers. By September, having left the Indian corn, which at this time was becoming dry, the young bugs were plentiful on cane and kafir. These bugs matured on the cane, kafir, and succulent grasses, and large numbers went into hibernation in the fall among the grasses.

The spring of 1909 was quite late in opening. A big snow on March 8 remained on the fields until March 20, and for several days afterwards the ground was alternately wet and frozen. During the last two days of March there was bright, warm sunshine, and the bugs began to move about. On April 3 the bunches of sedge grass, *Andropogon scoparius*, in which the insects hibernated, resembled living masses of crawling bugs, and before nightfall great swarms were flying; this continued during the next few days, and the wheat fields had now become badly infested. The chinch bugs commenced mating very soon after reaching the wheat fields, and in a few days egg laying began. Eggs were very numerous about wheat plants by April 22, some were hatching, and by May 1 young bugs were abundant. The massing in large numbers on single plants, which was so noticeable in the spring of 1908, was entirely lacking in 1909; seldom were there more than a dozen bugs on a plant, although nearly every plant was infested.

The entire month of April, together with the first ten days of May, 1909, were exceedingly dry and wheat suffered from lack of moisture. There was no noticeable injury to the young wheat from attacks of the old hibernating bugs and not much from the combined attack of both the old and young bugs, until the first week of May, when the wheat failed rapidly, owing to the great number of the insects and the lack of moisture. Here, again, heavy rains of four days (May

11–14) checked their ravages and killed great numbers of both the young and the old bugs. The rains were light from May 15 to 27, and during this interval the young chinch bugs became very abundant. On some wheat plants there were as many as 240 young bugs, while other wheat plants were free from them; infested wheat plants turned yellow and died, owing entirely to the effects of their attack. The heavy downpour of rain on the night of May 27 buried thousands of chinch bugs in the loose soil and again put a temporary check on their ravages. This rain was the last one of any importance until the night of June 22. By June 8 most of the bugs had changed to a brown color and few red ones remained among them; several eggs were observed on wheat roots. By June 14 the young chinch bugs were very abundant on the stems and leaves of wheat, and 300 to 500 bugs per tiller were counted on several plants, which were turning white and dying before the grain had matured. The ground was covered with moving insects but in no instance were the chinch bugs leaving the wheat fields. Five days later the wheat was prematurely "ripened" through insect attack and the hot sunshine. The "ripening" grain forced them to seek food elsewhere and on June 21 they began to migrate from wheat to corn. The grains in the heads of the severely attacked tillers were small and considerably shriveled, while grains in heads which had not been attacked were full size and plump. Great numbers which were migrating on June 22 were temporarily checked by a light shower, only to continue the movement as soon as the grass became dry. At night, however, a very heavy beating rain fell, burying millions of bugs of all ages and sizes in the mud. The mud-covered bugs nearly all died and those not dead by the next day were found stuck fast in the mud. The ground dried out by noon of June 24, and the bugs that were not killed by the rain continued migrating toward the cornfield. In an area of 4 square feet in a wheat field there were 2,411 dead chinch bugs, some of them buried one-half an inch in the soil. In an area of 10 square feet in the same field there were only 244 living chinch bugs, all of which were moving toward an adjacent cornfield where they collected in masses on the outer rows.

The weather was quite dry during the next few weeks and the bugs did considerable damage to young corn, some fields being almost devastated. The bugs began to transform to adults about July 5, and their ravages ceased within a week thereafter. There were hordes of adult bugs scattered throughout the cornfields, and these were mating and depositing eggs.

By the middle of August, when most of the corn had matured and dried, there were again great numbers of young bugs on the corn plants even under the outer husks below and about the bases of the ears; the greener plants were much infested. The corn now began

to get too dry to afford them food and they began migrating to kafir, sorghum, and grass fields, killing all crab-grass and panic grass in the cornfields before they left them. Some bugs were observed in alfalfa fields but at no time were they feeding on the alfalfa.

During October and early November several chinch bugs were observed on young wheat and a few eggs and young larvæ of the third generation were observed. They did not damage the wheat during the late fall, and by the middle of November had left the wheat fields for winter quarters.

The kafir and cane were green until the middle of September, and great numbers of chinch bugs were feeding on these two crops at this time when the crops were harvested. They remained on these plants and were put into the shock, where they were observed on several occasions during the fall, but they all left before cold weather set in.

During early fall a few bugs were to be found in nearly every situation on the farm—some in corn husks, some in alfalfa fields under the leaves, and some among sparsely growing grasses, but most of them were in the bunches of clump-forming grasses along fences, roadsides, and railroad rights of way, in waste places, and in meadows. That the weather conditions of the summer and fall were the most favorable for the chinch bugs is indicated by the vast numbers that went into winter quarters. Some of the bunches of the red sedge grass (*Andropogon scoparius*) contained from 10,000 to 20,000 bugs, this grass affording them the most attractive and favorable hibernating quarters.

The severe cold weather of December, 1909, was disastrous to bugs that failed to reach some of the clump-forming grasses, and very few bugs in corn husks and among thin grasses survived the winter.

SOUTHERN KANSAS AND NORTHERN OKLAHOMA, 1910.

In southern Kansas and northern Oklahoma the spring of 1910 opened the last week of March with warm, dry weather. The chinch bugs began to migrate to the wheat fields; on March 24 the air was full of flying adults and by March 26 the wheat fields were badly infested. The weather turned much warmer about April 1, the chinch bugs began mating, and by April 10 were depositing eggs about the wheat roots; by April 20 the eggs were very abundant—hundreds on the exposed roots of every plant. Not many eggs hatched during April and the first 10 days of May on account of the cool weather, but they hatched profusely during the next few days, so that by May 20 the fields were overrun with myriads of very young chinch bugs.

Wheat throughout southern Kansas and northern Oklahoma had been severely winterkilled, which, together with the exceedingly dry spring, left the plants in a very weakened condition. The soil was so dry during April and May that the small amount of rainfall

was of little value. The ground was badly cracked, exposing the wheat roots to the hot sun and drying winds and these, together with the bugs, killed a great many plants. Wheat was so badly killed, mostly by meteorological influences, that by May 1 thousands of acres had been abandoned and corn planted in its stead. The young bugs and eggs were little molested by the operation of corn planting and as soon as the sprouting corn pushed through the soil hundreds of bugs were ready for every plant. Some such fields were even planted the third time only to furnish food for these hungry insects. The bugs would crawl from beneath several inches of loose soil and be ready to attack the young plants as soon as they appeared.

Such wheat as was not abandoned made a poor growth on account of drought and was severely damaged by the chinch bugs, great numbers of which were on every plant, so that by June 10 they had sapped the life from them. As the wheat and grasses were killed by the drought, the bugs were forced to abandon wheat fields and hunt for food elsewhere. The corn, which had made very poor growth up to this time on account of the lack of moisture, was very small and weak when the bugs reached it, and this early attack by the young chinch bugs resulted in the devastation of thousands of acres before the bugs became mature. On reaching maturity they abruptly dispersed and their depredations were brought to an end.

Young bugs of the second generation became numerous the first week of August on the cornstalks under the sheaths and under the outer husks of the ears. Corn leaves, stalks, and husks of ears were dry by the middle of August and bugs were moving out of these into fields of kafir and sorghum, both of which suffered under their attack, many fields being laid waste by September 1. Owing to the continued drought throughout the fall the Indian corn, kafir, cane, and grasses died leaving the chinch bugs without sufficient food supply, with the result that of the vast horde of bugs hatching in August comparatively few survived to go into winter quarters. During September and October a few young chinch bugs matured on volunteer wheat, later depositing a few eggs for a partial third generation. No damage was done to wheat by these few insects, although some of them remained on or about the wheat plants till cold weather set in. There were not nearly so many chinch bugs in the bunches of grass in the fall of 1910 as in the fall of 1909.

KANSAS, 1911.

As previously indicated, the fall of 1910 was very dry and wheat failed to sprout in Kansas and Oklahoma. The winter of 1910–11 and the spring of 1911 continued dry, very little rain falling during the entire period till the last of May, 1911. This extended drought

affected both crops and chinch bugs to such an extent that wheat was almost a failure and the numbers of the bugs were greatly reduced. The winter wheat which was seeded in September and October, 1910, was seeded in a very dry soil; very little of it sprouted. A few localities were favored with a shower of rain in September which sprouted the grain, and the bottom fields along the rivers and creeks contained enough moisture to sprout the grain and produce a fair crop. As a result of the drought, however, very little wheat matured on the uplands.

The chinch bugs went into hibernation in a very weakened condition because the grasses had dried up in the fall. Many of them did not reach their usual winter quarters but stopped in almost any place they could find. Many hibernated in trash in alfalfa fields where a small percentage succeeded in living through the winter. The death rate of hibernating bugs was greater than in any previous winter included in this study; in some of the bunches of Andropogon 60 per cent of the bugs were dead. When the first warm days of spring occurred the few bugs that were left were very inactive and the migration to green fields, which had been so noticeable in former years, was lacking. However, there was a migration during some very hot days in the latter part of April—over a month late. The dying of the bugs during the winter was probably due to two causes, one being the starved condition of the bugs when they went into hibernation and the other the hot days during the winter followed by the very cold days in the spring. During these hot days in the middle of winter the bunches of grass would be swarming with the bugs and the very next day the thermometer would register 8 to 10 degrees below zero. In spite of all these adverse conditions many of the bugs lived to infest the fields in the spring.

The failure of wheat caused the farmers to plant other crops in many of these fields, but some of them were left standing until May in the hope that a crop would be produced. The bugs reached the few fields that were left, damaged the plants considerably, and deposited numbers of eggs. Many wheat fields were seeded to oats after the wheat failed, thus leaving the few wheat plants growing in the fields for the young bugs to feed upon. At no time could young bugs or eggs be found on the oat plants. Notwithstanding the fact that numbers of farmers lost several plantings of corn in 1910 by planting the infested wheat field to corn, hundreds of acres of corn were planted in such fields in the spring of 1911, only to be destroyed later. There were areas of 8 to 10 square miles that did not contain an acre of wheat after the middle of May, all of the fields having been planted to other crops. In these localities where the wheat was missing the bugs were also missing, and where the wheat was plentiful the bugs were very plentiful and did considerable damage to adjacent corn.

It is very apparent that wheat has a decided effect on the presence of the chinch bugs, as indicated in the localities where the wheat was a failure this spring.

The dry weather had its effect on the fungus, *Sporotrichum globuliferum*, and it has not occurred in the fields this season (1911). Only once has it been possible to secure it in the laboratory. Continued search has been made for it in all kinds of places, especially after the rains in May and in July, beyond which latter month this record does not extend.

HIBERNATION.

At the beginning of the investigation the advisability of getting rid of the chinch bugs before they entered the young wheat in the early spring was very evident, for when once they have reached there they are not readily accessible. This led to a series of observations on their hibernating habits for the purpose of determining the places preferred by the bugs.

The current belief that most of the bugs pass the winter beneath corn husks, among cornstalks, in fence rows, under boards and rails, in heaps of rubbish, in straw stacks, along hedgerows, and in fodder shocks is not borne out by investigations in Kansas and Oklahoma following a severe winter. When the bugs are very abundant, as they were in Kansas, Missouri, and Oklahoma during the fall of 1909, a few may be found in any of these situations, especially in the early fall. The most of the bugs find their way to thick bunches of clump-forming grasses in waste places, in pastures and meadows, and along roadsides and railroad rights of way. During late fall and early winter great numbers of living bugs can be found in corn husks, fodder shocks, piles of kafir, cane, and in most any place covered with vegetation—even in alfalfa fields where they find no food. In the spring, however, very few living bugs but many dead ones can be found in such situations, indicating that most of them died there.

They find much better protection in the thicker and more dense, than in the thinner grasses and under trash in open fields. The bugs seem to prefer the thicker grasses, though they are quite often found in other situations, and after open winters, as the one of 1910–11, many living ones can be found under very thin protection. Many living chinch bugs were taken from trash collected in an alfalfa field and some were found in corn fodder and corn husks lying on the ground on February 24, 1911, at Wellington, Kans., though most of the chinch bugs are at this time in the thick bunches of sedge grass.

The situation in southern Illinois for the spring of 1911 was quite similar to that in southern Kansas; there were abundant clumps of Andropogon along roadsides, in fields, and in woodlands, and more chinch bugs were found in these clumps of grasses than in trash,

under boards, or in any other place. There were not a great many bugs in any one place, however, and it would be rather difficult to make a conclusive comparison between the two widely separated localities, although the indications are that the majority of the bugs seek the thick grasses in which to hibernate.

The destruction of the hibernating chinch bugs is of much importance; it has been discussed frequently and is strongly recommended by entomologists throughout the United States. As the methods of farming, the prevailing crops, and the wild grasses vary in different localities where chinch bugs occur, the places of hibernation may also vary considerably.

Mr. C. L. Marlatt, of this bureau, in an article on the hibernation of chinch bugs,[a] has the following to say:

> In nearly every account of the chinch bug which I have seen, stress has been placed on the hibernation of the adult in rubbish of any sort, such as piles of corn fodder, hay piles, straw piles, and dried leaves along hedgerows. In course of very careful investigation carried on in Kansas during a year of excessive abundance, I failed entirely to find any basis for the above supposition. Repeated careful search throughout the late fall and winter failed to discover a single living chinch bug in such situations.
>
> Failing to find them in the situations noted, I carried the examination further and finally discovered what is probably the normal hibernating place of the chinch bug in the dense stools of certain of the wild grasses, such as the blue stem and other sorts. * * * So marked is this hibernating habit that it is reasonable to infer that it is the normal and ancient one of the species, the natural food plant of which, before the advent of settlement and growth of the cereals, must have been some of our native grasses.

Mr. H. W. Brittcher, in regard to hibernation,[b] says:

> * * * they may frequently be found, more or less closely crowded, low down among the stems of clumps of wild rushes and grasses, often working their way down between the stems and the soil.

He recommends burning the sedges in which careful examination showed the bugs to be abundant. It must be remembered that in Maine it is the short-winged form that prevails and is there a grass as well as grain destroying insect.

In regard to hibernation,[c] Dr. S. A. Forbes, State entomologist of Illinois, says:

> On the 7th of November a careful search was made in corn that had previously been badly infested by them, but none were to be seen upon the stalks or under the rubbish on the ground in the field; in the thickly matted grass adjacent only a single specimen was discovered by 15 minutes' search. On the 14th of this month the weather was cold and raw, and the ground was frozen about the hills of corn from an inch to an inch and a half in depth; a very few bugs were now found in the crevices of the ground, among the roots near the surface. At Champaign, on the 15th, I visited again the field of Bogardus and Johnson, making a careful search for hibernating individuals about the

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[a] Insect Life, vol. 7, pp. 232–234, 1894.

[b] 19th Ann. Rept. Maine Agr. Exp. Sta., 1903, p. 42, 1904.

[c] 12th Ann. Rept. State Ent. of Ill., pp. 37–38, 1903.

stalks, under the weeds in the field, and beneath the rubbish collected about the hedgerows. Not a single specimen was found in these situations, although every temptation was afforded to hibernating insects, and many other species occurred abundantly. To what resorts the swarms which had developed in these situations had betaken themselves to pass the winter, I am not able to say.

Prof. Herbert Osborn,[a] in giving a summary of his observations on the chinch bug in Iowa in 1894, states:

> In a great majority of cases, 90 per cent or more, the infested fields were directly adjacent to hedges or thickets or belts of timber, and in 75 per cent osage-orange hedges were the most available shelter. In about 13 per cent of cases the evidence showed hibernation in grass and weeds and in some of these cases there could scarcely be a doubt that the hibernating bugs were protected by a heavy growth of grass or weeds and that they moved from these directly into adjacent fields.

Prof. F. M. Webster, of this bureau, has probably given the chinch bug more attention than any other entomologist and has contributed more to our knowledge of the pest. His observations in Ohio and those made by Prof. Herbert Osborn in Iowa are at variance with those made in Kansas by Mr. Marlatt and by the writers. Prof. Webster offers the following explanation [a] of their hibernating habits in different localities:

> In Kansas, where Mr. Marlatt made his observations, there was still too much prairie, and the species was doubtless still adhering to its ancient habits of hibernation. In southern Ohio the author has found it attacking the wheat in May, in small isolated spots over the fields, while there was nothing in the least to imply an invasion from outside, but the wheat had been sown in the fall among corn, and later the cornstalks cut off and shocked, remaining in this condition until the following spring. This occurred so frequently that there seemed no room to doubt that the attacks had been caused by adults wintering over in the corn fodder and that these left their winter quarters in spring to feed and breed on the grain growing nearest at hand.

The hibernating habits of the chinch bugs have been closely observed during two seasons in Kansas and Oklahoma, and the observations made indicate that the bugs hibernate there chiefly in dense clumps of sedge grass, principally those of different species of Andropogon.

The following data with reference to the hibernating habits of the chinch bugs were made by the writers in southern Kansas, and are given here to substantiate the above statement:

From Mr. Hayhurst's notes made in the fall of 1907: On October 26, at Winfield, Kans., he found active adult chinch bugs in stools of broom beard grass (*Andropogon scoparius*) in great numbers, always close to the ground. On November 1, 1907, at Newkirk, Okla., he again found many active bugs in the stools of forked beard grass (*Andropogon furcatus*) close to the ground. They were present in nearly every stool of this grass examined along roadsides and also on the open prairie where the grass had been cut.

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[a] Bul. 69, Bur. Ent., U. S. Dept. Agr., pp. 16–17, 1907.

At Wellington, Kans., the senior author, on October 3, 1908, observed adult chinch bugs flying and collecting in grass (Andropogon) down at the crown, and on October 12 he saw hundreds of bugs in some clumps of this grass along roadsides. During the early spring of 1909 hundreds of living adults were found in clumps of this same grass, where they had evidently hibernated. On November 30, 1909, in this same locality the authors observed some bunches of *Andropogon scoparius* containing 6,000 to 10,000 bugs each, and on November 29, 1909, they found a few living bugs in corn husks, but most all of the bugs were in bunches of grass. Again, on December 22 one bunch of Andropogon 2 inches in diameter was found to contain 1,508 bugs; many bunches were 8 to 12 inches in diameter, and contained as many as 15,000 to 20,000. Bugs were found only in grasses that grow in clumps; none was discovered in rubbish, old straw piles, fodder shocks, or in sorghum-cane piles. Several dead bugs were found in corn husks, but no living ones. A number of bugs collected at random from the base of some bunches of Andropogon was brought into a warm room to see how many would revive. There were 325 living bugs and 89 dead ones, or 21.5 per cent dead. None was found in bunches of reed grass (Calomagrostis), Sporobolus, blue grass (Poa), or crab grass (Digitaria).

The method for separating the living chinch bugs from the trash and dead bugs was a very simple one. The bugs and bunch of grass containing them were put on paper in an oblong box, and the box placed in front of a fire, where the living bugs would readily crawl out of the grass and trash to the corners of the box and beneath the paper. Care was taken not to heat the bugs to more than 100° F., as a higher temperature might kill them.

On December 24 another lot of chinch bugs, collected at random from clumps of Andropogon and brought into a warm room, gave 755 living and 234 dead, or 23.6 per cent dead. Again, on December 29 a third lot of bugs in clumps of Andropogon was brought into the laboratory, where the warmth of the room soon revived them, and they became active. Of this lot of bugs 20 to 25 per cent were found to be dead, probably from exposure to cold or perhaps from old age. On December 30, corn husks and the husks of fallen ears, which had not been harvested, were searched for living chinch bugs. Very few were found and none whatever about old straw piles. Very few bugs died during January, as indicated by observations during the last part of that month. Three lots of bugs were collected from bunches of Andropogon; the first contained 298 living and 72 dead bugs, or 19 per cent dead; the second contained 137 living and 35 dead bugs, or 20 per cent dead; the third, which was collected on February 12, 1910, contained a few more than 10,000 counted bugs, 20 per cent of which were dead.

The weather was somewhat drier, but agricultural conditions for the fall of 1910 were about as those of previous years, except that vegetation was practically all dry before frosts. Chinch bugs were not nearly so numerous as in the fall of 1909, clumps of Andropogon containing only 80 to 260 bugs each, whereas there were thousands the previous winter. During the early fall it was again observed that the corn husks were full of adult bugs, but by cold weather these were nearly all dead; the mild winter, however, permitted some of these bugs to live through, and some were alive on February 24, 1911.

From the foregoing data, covering four seasons, there can be little doubt that in Oklahoma, Kansas, Missouri, and probably southern Illinois these clump-forming grasses form the principal hibernating quarters of the pest. This definite knowledge of their habits puts a most practical and effectual weapon into the hands of the farmer, which he may apply months in advance, in defense of his crops.

The farmer can readily determine whether the grasses on or about his farm contain chinch bugs by pulling open the tufts of red sedge grass. (See Pl. V, fig. 3.) If the bugs are present in these clumps of grasses, it is of the utmost importance that they be burned. The habits of the hibernating generation and the migration of the spring generation offer the best opportunities for forestalling and preventing future ravages.

PREVENTIVE MEASURES RECOMMENDED.

DESTRUCTION OF CHINCH BUGS WHILE IN HIBERNATION.

The burning of grasses and rubbish about the farm to destroy chinch bugs has been often recommended and is doubtless the most effective measure to be taken against future ravages of the pest.

In the Southwest the chinch bugs are known to congregate in bunches of grass in late October and remain there till the warm days of early spring. It is only a matter of burning off these grasses at the proper time to effectually rid such places of the pest, and the grasses are generally sufficiently dry to burn readily by the 1st of November. The chinch bugs crawl deep down among the grass stems, a few of them even getting beneath the dust and débris, thus seeking protection from the freezes that are to come. It is very important that the grass be dry and yet burn slowly, so that the heat will thoroughly penetrate the dense grass and reach the bugs. It is not necessary for the fire to come into direct contact with the bugs in order to kill them, as they died very quickly in the laboratory when exposed to the heat of a flame from 12 to 20 inches distant, the fatal temperature being in these experiments about 111° F. Fall burning of the grasses among which the bugs are congregated has a

FIG. 1.—PILE OF SORGHUM CANES IN WHICH NO HIBERNATING CHINCH BUGS COULD BE FOUND. (ORIGINAL.)

FIG. 2.—WASTE LAND ALONG STREAM IN FOREGROUND, SEDGE-GRASS MEADOW IN BACKGROUND; CHINCH BUGS FOUND HIBERNATING IN BOTH. (ORIGINAL.)

FIG. 3.—CLUMPS OF RED SEDGE GRASS (ANDROPOGON SCOPARIUS) IN WHICH OVER 6,000 CHINCH BUGS WERE FOUND HIBERNATING DURING WINTER OF 1909-10. (ORIGINAL.)

HIBERNATION OF THE CHINCH BUG.

twofold value; first, it will kill large numbers of bugs directly; and, second, the bugs not killed by the fire will be left exposed to the winter freezes, which of themselves will in ordinary seasons kill many of them. On several occasions during fall and spring bugs were removed from the stubs of burned grass and the percentage of dead and live bugs obtained. On an average about 75 per cent were killed in the fall and about 63 per cent in the spring. In the spring about 20 per cent of the bugs, which hibernated in the clumps of grasses, were dead from exposure and other causes. From natural causes and burning in spring, there were about 83 per cent of the bugs dead. These percentages were obtained by actually counting the insects and are not from estimates. The fire can not reach all the bugs, even with the most careful burning, because of protection afforded by green or wet stems in early fall and late spring; therefore it is essential that the grass be burned during late fall or early winter. While this remedy is recommended above all others, its effectiveness is entirely dependent upon the farmers and their cooperation, and it is an easy matter for neighborhoods to combine in an effort to fight the pest in this manner.

DUST BARRIERS.

If the bugs are not killed out during hibernation, the main dependence of the corn grower must be in the destruction of the bugs as they migrate from the ripening small grain to enter the cornfields. As soon as the ripening grain compels the bugs to desert it and they start for the corn, a narrow strip of ground between the corn and wheat should be deeply plowed and thoroughly pulverized, making a dust bed. Then a short block or a triangular box should be made in form of a sled with the bottom fitted with a seat for a driver. This should be dragged back and forth in this dust bed until a deep groove or furrow has been made. If this furrow has been well prepared, and the weather continues dry, it will prove an impassable barrier to the progress of the bugs. In order that this kind of barrier may be successful, the block must be kept in constant use, from early until late and sometimes well into the night. Often, during the migration, the bugs travel all night. Slight showers render dust furrows useless and if a shower is pending, and under such weather conditions, it is best to employ the coal-tar barrier. Owing to the fact that dry weather often prevails on the plains during this season the furrow method under these conditions is especially recommended.

COAL-TAR BARRIERS.

The coal-tar barrier can be operated successfully in the Middle-Western States to prevent the bugs from migrating to young corn. The success of this measure depends on the farmer and his careful

attention to the tar line. Preparations for the barrier should be begun in all cases where the bugs are found abundant in ripening grain. Frequently the soil is quite compact along the margins of wheat fields and if it is, a smooth path can be readily fixed at the edge of the field next to the corn. If the soil is not compact it is well to throw two furrows together, making a ridge, and with a heavy block make the top of it very smooth and compact. Along this smooth path, post holes 12 to 18 inches deep should be dug about every 20 or 30 feet. Get a supply of coal tar, or if it is more convenient, pine tar or crude oil, ready to use as soon as the bugs begin to travel. An old coffee pot with the spout pinched so as to allow a small stream to flow is convenient for putting the line of tar on the patch. By holding the vessel near the ground a narrow line no wider than a pencil can be made, and this is all that is necessary. The tar line should strike the post holes near the middle extending directly around the edge of the hole on the side next to the corn, leaving the edge of the hole next to the wheat free. When the chinch bugs reach the tar line they will not cross it but will turn aside and run or crowd each other into one of the post holes. As soon as the holes are partially filled with bugs a small amount of kerosene poured in them will kill them. Care must be taken in putting the line around the post hole so that the assembling mass of bugs does not crowd over it. When first applied the material will soak into the ground, but a hardened crust will readily form which will hold it until it slowly dries out. The line must be closely watched and renewed as often as the bugs begin to break over it. Wherever the soil is sandy and very loose a slight windstorm will cover the tar, making passageways for the bugs, and under such conditions the line must be renewed quite often. A man or boy can care for from 80 to 100 rods of the barrier, but he must stay with it from early till late. Ordinarily the bugs will have finished their migration from wheat in 10 days. This method is apparently costly and troublesome, but the actual expenditure of labor and money is insignificant as compared with the loss of the corn crop which may thus be prevented.

REMEDIAL MEASURES.

DESTROYING BUGS WHICH ENTER CORNFIELDS.

After the bugs enter the cornfields they will at first collect in masses on the plants of the first two or three rows and should be killed before they proceed farther. This can be done in two ways, by applying a gasoline torch and by spraying them with specially prepared solutions.

The flaming torch is not altogether satisfactory on account of the liability of damaging the plants. Great care must therefore be

taken with the flame in order to use it safely and effectively. The flame must be in motion all of the time while on the plant, and generally one blast will cause all the bugs to fall to the ground, where they can be burned.

There are several spraying materials which can be used effectively against the bugs after they have congregated on the young corn, but, unfortunately, most of these are injurious to the plants. Kerosene emulsion of 5 per cent strength will generally kill the bugs and will not always injure the corn. The stock solution is made by boiling 1 pound of good lye soap in 1 gallon of water, adding this to 2 gallons of kerosene and stirring the mixture with a paddle for five to ten minutes. A better way to stir the mixture is to put the nozzle of the spray in the vessel and pump the liquid back into the vessel for five minutes. Dilute the mixture to a 4 or 5 per cent solution by adding soft water. Some of the proprietary spraying materials and cattle dips have been used to kill the bugs where they have become alarmingly abundant. One serious objection to these materials is that they are very injurious to the plants. However, it is sometimes better to sacrifice the first few rows and save the field than to let the bugs have their way.

UNSATISFACTORY REMEDIAL MEASURES.

GREEN-CORN BARRIERS.

Cutting the first half dozen or dozen rows of green corn and making a continuous pile along the last row cut is a method of creating a barrier very often employed. The green-corn barrier is made about the time the chinch bugs begin to enter the corn. The bugs are checked an hour or two by the corn pile, but readily pass on to the fresh, living plants.

The piles of corn plants afford shelter for the bugs, and often a quart of cast skins can be found in a heap under these piles. These cast skins have often been misleading to farmers, inducing them to believe that the bugs died from eating the sour juices of the cut corn or having died from disease. *A barrier of this kind is not to be recommended.*

PLOWING UNDER INFESTED CROPS.

As the chinch bugs in the Southwest do not hibernate in cornfields, plowing under of stalks and stubble in such localities will be of no advantage. It has been repeatedly shown that plowing under a crop of wheat, rye, or barley badly infested with young bugs is not effective unless the plowing is deep and very thoroughly done and the field is immediately afterwards harrowed and rolled.

In experiments conducted by Dr. Forbes in 1888 [a] bugs buried with wheat at a depth of 6 inches were alive after five days and some buried 5 inches came to the surface. The earth was packed over these to imitate rolling.

E. M. Shelton,[b] from observations in Kansas, writes:

> Chinch bugs plowed under with young wheat to a depth of 8 inches May 9–10—the ground afterwards harrowed and repeatedly rolled—nevertheless emerged in enormous numbers (some having apparently hatched in the earth), escaped from the plots and attacked adjacent crops.

Because of the wheat being winter-killed in central and southern Kansas and northern Oklahoma during the winter of 1909 and 1910 many of the wheat fields containing young and old bugs and eggs were listed during April, at the time when the eggs were hatching. In many cases corn was listed directly into the wheat ground, tearing up the young wheat, but not entirely destroying all of it between the rows of corn. The eggs and young bugs were buried from 1 to 6 inches. The undestroyed wheat was soon covered with young bugs, which afterwards attacked the corn as soon as it appeared above the ground.

Even in fields where no wheat was visible after listing the corn was entirely destroyed. There is every reason, the authors believe, for presuming that the eggs hatched beneath the ground, and the young, after feeding there, had found their way to the surface and to the corn. Corn listed in fallow ground was free from bugs. Planting of corn in wheat fields badly infested with chinch bugs is not advisable, and is generally attended by the complete destruction of the corn. When a badly infested crop is plowed under it should be followed by a crop not affected by chinch bugs, such as cowpeas, soy beans, alfalfa, or clover. Plowing the bugs under as a means of destruction is not recommended unless in connection with a trap crop, the work being thoroughly done and followed by harrowing and rolling or otherwise packing the surface of the ground.

PARASITIC FUNGI.

EARLY OBSERVATIONS.

The susceptibility of the chinch bug to a contagious fungous disease was first observed by Dr. Henry Shimer in Illinois in 1865. Since that time two fungi have been found, which are credited with being fatal to this insect. These have been determined as *Entomophthora aphidis* Hoffman, and *Sporotrichum globuliferum* Speg. Of these two fungi, Sporotrichum (known by farmers as "fungous disease" or "white fungus") appears the most abundant in localities badly

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[a] 16th Rept., State Ent. Ill., p. 45.

[b] Bul. No. 4, Kans. Agr. Exp. Sta.

infested with chinch bugs, and it is on this fungus that most observations have been made.

The genus Sporotrichum includes a large number of fungi, the most of which are purely saprophytic (i. e., living on dead animal or vegetable tissues). According to the best information obtainable, some of these are known to attack living tissues, causing their death, but afterwards developing rapidly on the body of the dead host. *Sporotrichum globuliferum* belongs to the latter class, and is known to occur on insects belonging to the orders Coleoptera, Lepidoptera, Hemiptera, and also on myriapods (centipedes and millipedes). It is credited with effectively attacking the elm leaf-beetle, the pupæ and adults of which are found covered with the fungus, especially in late summer of a moist season.[a]

Attempts have been made in most of the Central-western States to grow this fungus under artificial conditions, and then introduce it into fields badly infested with chinch bugs, where the fungus is not known to be present. With the possible exception of the Kansas experiments, made by Dr. Snow in the early nineties, these attempts met with little success. In most cases some unfortunate circumstance always arose to make the success of the experiment uncertain. (This fungus requires rather cool, moist weather for most rapid development, and is present in greatest profusion when the bugs are exceedingly plentiful and massed together.) In many of the early attempts at artificial introduction, Entomophthora was present as well as Sporotrichum, thus giving rise to some confusion concerning just which fungus was credited with actually killing the bugs.

The most important of these experiments are fully set forth in the reports of the State entomologist of Illinois and in Bulletins 15 and 69 and Circular 113 of this bureau, and therefore require no extended discussion here.

OBSERVATIONS BY THE WRITERS.

FIELD STUDIES IN KANSAS AND OKLAHOMA.

It is fully realized by the writers that the determination of the cause of a disease is most difficult, and that it requires extended laboratory research along many different lines. To state that this fungous disease is the cause of the mortality among the chinch bugs, without this extended laboratory investigation, would be entirely unscientific. The observations given here are published for what they are worth.

Observations on the habits and occurrence of the fungus were made in Kansas and Oklahoma during the spring of 1908 and 1909, and the spring and summer of 1910. Some additional data were obtained with respect to its behavior in the field among chinch bugs of all ages

[a] Conn. Agr. Exp. Sta., Bul. No. 155, 1907.

and under varying weather conditions. Most of the observations were made in Sumner County, Kans., where the fungus had probably been present among the bugs in the fields for a number of years. Considerable fungus was present during 1908 and 1909.

It again appeared among the chinch bugs in southern Kansas during April, 1910, and was first observed in the fields April 18 on the dead bodies of some adults lying on the ground at the base of young wheat plants. From this date the fungus gradually increased, dead adults covered with fungus being found almost every day. These were always on the soil, or slightly buried beneath the surface, about the roots of wheat.

During the first week of May the weather was cool and rainy, the mean temperature of the week being 59° F. and precipitation 0.75 inch for four days. The bugs, during this period, were sluggish and sought shelter under blades of wheat or any trash that would keep them off the ground. Succeeding this week of wet weather, followed two hot days, with a mean temperature each of 68.5° F. and 79.5° F. At the end of this period the following note was made:

A number of dead bugs were found lying on the ground, their bodies whitened with the fungus. One plant had 7 dead, fungus-covered bugs at its base. No young bugs found covered with the fungus.

From notes of May 18:

A great many old bugs are dead and covered with the Sporotrichum, but failed to find any young bugs covered with this fungus. The dead bugs are on the surface of the soil.

About this time the young bugs which had hatched from the eggs deposited in the wheat were massed together about the bases of the wheat plants. Where the wheat had winter-killed, and had been torn up and corn listed into the ground, the bugs which hatched on the wheat had gone to the nearest corn plants. Some stalks of these plants were red from the myriads of young bugs assembled upon them; in no case could any fungus be found on these young bugs, but there were usually a few overwintering adults to be seen about the base of these plants, and upon turning over a clod some of their dead bodies covered with Sporotrichum were usually to be found. Plenty of the fungus could be found at this time in wheat fields where the adult hibernating bugs were still present. Sporotrichum gradually became more abundant during the succeeding days of May and early part of June, the amount observed seeming to fluctuate with the weather, being most abundant while it was damp and cool and checked by a few days of dry weather. It developed most rapidly in wheat fields during the first 10 days of June, while the bugs, both young and old, were migrating from the wheat to the corn, the fungus being at this time abundant on dead adults in contact with the soil and in some cases on the bodies of young dead bugs.

At this time attention was transferred from the wheat to the cornfields where very little fungus was noted, most of the old bugs being dead, and the young ones seemingly free from any fungus. Some of it could be found on the bodies of the adults about the base of the corn, just as observed about the corn which had been listed in the wheat infested with the bugs; none, however, could now be found above the surface of the soil, all fungus being either below or on the surface of the ground.

The bugs were now seriously damaging the corn, as will be seen by the following note made on June 15:

> Bugs still migrating from wheat to corn. They are out for 40 and 50 rows on corn adjacent to wheat. No Sporotrichum is developing.

The farmers of Sumner County were informed of the presence of the fungus in this locality, through the press, and by interviews with them at the laboratory at Wellington. On June 24, two reports came from the farmers that the fungus was killing off the bugs. Visits were made to their farms, and the "dead bugs" proved to be only piles of cast pupal skins, which they had found beneath piles of green corn, and bundles of wheat and oats. This same mistake on the part of the farmers was made during the experiments of Dr. Snow in 1891. In reports of farmers to him we quote: "In some fields the bugs have been reported dead in bunches," but he continues "of the fields visited, no large bunches of white-fungus bugs have been found, * * * each bug had died by himself." [a] This confusion of the fungus-killed bugs with their cast-off pupal skins is one frequently made by farmers, and such reports in regard to the efficiency of the fungus are very apt to be erroneous.

On June 23 the bugs began to leave the badly infested corn, as the young had now developed wings. By July 1 they were so widely scattered over the corn as to give the appearance of having left the fields. In some instances this apparent disappearance of the bugs was credited to the fungus by those who had not been constantly watching them, several farmers reporting that the fungus had killed their bugs because there were so very few to be found.

Heavy rain fell on July 8 and 10, but little Sporotrichum could be found among the bugs in the corn. On July 19 a few dead adults located on corn leaves from 1 to 2 feet above ground were observed covered with Sporotrichum. This was the only case during the summer where the fungus was observed not in contact with the ground. At this time an examination of the wheat stubble was made and the following note made:

> In pulling up wheat stubble large numbers of dead fungus-covered bugs were found in some places, the soil about the wheat roots being speckled with the fungus.

[a] 1st Report on Contagious Diseases of the Chinch Bug, F. H. Snow, 1897.

Particles of the fungus were found on dead adult bugs or a part of their bodies—some masses of white fungus covering only a broken abdomen, or a thorax with wing attached, by which the insect was identified. It appears that the fungus had developed rapidly on fragments of bugs and entire bodies of the bugs, especially when buried beneath the soil. The indications here were that much white fungus had made its entire growth on the dead bodies of the hibernating adults which had migrated to the wheat fields.

During the last week of July the weather was hot and dry and myriads of young bugs of the second generation, now feeding, sought shade under blades of corn, or beneath the clods at the base of the plant, but during this time no fungus developed. This condition prevailed until the middle of August, when wet weather again set in, and while this did not seem to increase the amount of Sporotrichum present, plenty of the fungus could be found in the soil around wheat stubble. However, this fungus seemed unable to infect the young bugs in the corn above ground, even where the cornfield joined the wheat stubble.

Sumner County, Kans., seemed to be about the center of the Kansas-Oklahoma chinch-bug infestation. With a view of finding out whether or not the fungus Sporotrichum was present in other places over the infested area, as well as to determine the extent of the infestation, a trip was made during June of 1910 through central and southern Kansas and central and northern Oklahoma, which represents pretty well the area infested during 1910 in this part of the Southwest. Twenty localities were visited, viz: Herrington, McPherson, Hutchinson, Pratt,* Dodge City,* Great Bend,* Sedgwick, Wichita, Winfield, Arkansas City, South Haven, Caldwell, and Caney, Kans.; Medford, Enid, Kingfisher, Elreno,* Chickasha,* Oklahoma City,* and Tulsa,* Okla. *Sporotrichum globuliferum* was found in every locality except those marked with an asterisk. The fungus covered bodies of the dead bugs were usually found lying upon the surface of the ground in wheat fields and in every case these were old migrant bugs, precisely as found in Sumner County, Kans. The seven localities where no Sporotrichum was found were all on the extreme outer edge of the infested area where there were very few bugs present. In every one of these seven localities the soil was very sandy, apparently not retaining moisture necessary for the development of the fungus.

ARTIFICIAL INTRODUCTION.—The fungus *Sporotrichum globuliferum* was already so abundant among the bugs in Sumner County during the summer of 1910 that no attempt was made upon the part of the authors to introduce it artificially. It seemed useless, since the amount already present so far exceeded any amount which could be introduced. However, a number of farmers anxious to try this

secured some Sporotrichum from outside sources and introduced it into their fields. These attempts were made independently and, as far as could be learned, no satisfactory results followed.

In the neighboring counties of Harper and Cowley, Kans., and Kay County, Okla., farmers united in spreading the fungus over their fields, after having grown plenty of it in boxes on their farms. This experiment was tried very thoroughly and on a very large scale in Cowley County, Kans., where the farmers secured the fungus from boxes of chinch bugs at two central stations, and after having grown more of the fungus in boxes on their own farms spread the whole over their fields where the bugs were thickest. The distributing points were Arkansas City and Winfield, Kans., and about 700 farmers secured fungus from the two boxes at these points. This was done in early June, and was followed by rainy weather just after the fungus was placed in the fields. The precipitation record at Wellington showed an aggregate rainfall of 0.82 inch on June 6, 7, 8, 10, and 11. When Cowley County was visited on June 21 it had been dry for a week preceding. The central distributing points were visited, and it was learned that a large quantity of *Sporotrichum globuliferum* had been distributed from these boxes. No satisfactory results were reported to the central station. Many of the farmers were interviewed, and in almost every instance the lack of success was attributed to the dry weather, which prevailed between June 12 and 21. In some localities every farmer had used some of the fungus. Upon visiting the exact spots where the fungus had been placed in the fields many bugs were found covered with white fungus; however, the fungus was as easily located in places remote from any artificial importation. The fungus was always put out in places where the chinch bugs were massed together. In consequence of this massing more fungus would normally occur in these places than elsewhere, regardless of the source of infection. The damage caused by the chinch bugs was fully as great where the fungus was introduced as it was in places remote from these, and also fully as great in this locality as it was in Sumner County, where no fungus had been introduced.

The parties who carried on this experiment were so united in their work, and extended it over such a wide area, that it constitutes one of the most satisfactory field experiments ever carried out with this fungus. From the results obtained we arrive a step nearer the actual position this method should occupy. There can be hardly a doubt that Sporotrichum was present before the experiment was tried, and that, too, in sufficient quantity to inoculate the healthy bugs. Since this failed to hold the bugs in check, no artificial introduction could accomplish what nature failed in doing.

Sporotrichum has appeared during the past three years in this part of the Southwest, and has not been effective as a natural enemy,

occurring chiefly among the old spent and therefore practically harmless bugs of the hibernating brood, they having already performed their mission of depositing their eggs. Since the fungus is so dependent on meteorological conditions, it can not be depended upon to exterminate the chinch bugs in this region. Farmers can accomplish a great deal more by employing methods more under their control.

OFFICE STUDIES IN WASHINGTON, D. C.

The following experiments were conducted at Washington, D. C., by the junior author who did the work on a table in an office room with no facilities for more elaborate experimentation. He entered into the investigation with a view of determining if the growth of this fungus is confined to the dead bodies of the chinch bugs and other insects, as the preceding field observations had, in most cases, borne out this supposition. These experiments led to a further study of the behavior of this fungus among living chinch bugs, and the results are here presented, in the hope that a better and more clear understanding may be had of what was observed to occur in the fields.

In these experiments the author is greatly indebted to Prof. F. M. Webster, of this bureau, under whose direction the work was done. Also to Dr. Flora W. Patterson, mycologist, Bureau of Plant Industry, for her valuable suggestions and kindness in determining the fungus.

Sporotrichum globuliferum was secured for these experiments by placing under a bell jar, on blotting paper kept constantly moist, dead bugs taken at Wellington, Kans., from beneath leaf sheaths of cornstalks, where they had died the previous autumn. The fungus was also secured by placing on moist blotting paper dead bugs collected in clumps of *Andropogon scoparius*, where the adults were hibernating but among which no fungus was observed. From 2 to 4 of all the dead bugs so treated became covered with the white fungus (fig. 15). The fungus was obtained also from live bugs collected from these same stools of *Andropogon*, confining the bugs in small cages of wheat kept well moistened. Some of these bugs died in the cages and on their bodies, lying upon the soil, the fungus appeared and was first observed eight days after the live bugs were placed in the cages.

During the spring of 1909, in the laboratory at Wellington, Kans., the senior author confined, on potted, growing wheat plants, numbers of living chinch bugs which were collected from tufts of *Andropogon scoparius*. The fungus appeared on several of the bugs which had died and were in the soil. He also obtained the fungus on adult dead chinch bugs collected from the tops of wheat blades and put on potted wheat plants. In these experiments the soil had been previously sprayed with a weak solution of corrosive sublimate for the purpose of killing any fungus spores that might have been present in the soil

in these cages, thus eliminating that source of infection. This indicates that the spores of the fungus were present on the bodies of the living bugs and were only awaiting favorable conditions for germination and abundant growth. In all such cage experiments the fungus appeared only on the bodies of the chinch bugs that had died in the cages and were lying on the soil.

In the experiments at Washington, D. C., it was desired to obtain a better knowledge of this fungus and its relation to dead bugs, in order to ascertain to what extent, if any, it will grow saprophytically upon their dead bodies. Also to observe the rate of mortality among live chinch bugs, placed in cages and artificially inoculated, as compared with those under similar cage conditions not so inoculated. In the artificial inoculation, the fungus was applied by thoroughly dusting the bugs with the spores of the fungus by means of a small brush, or in other cases by shaking them about in a vial containing the fungus-covered chinch bugs.

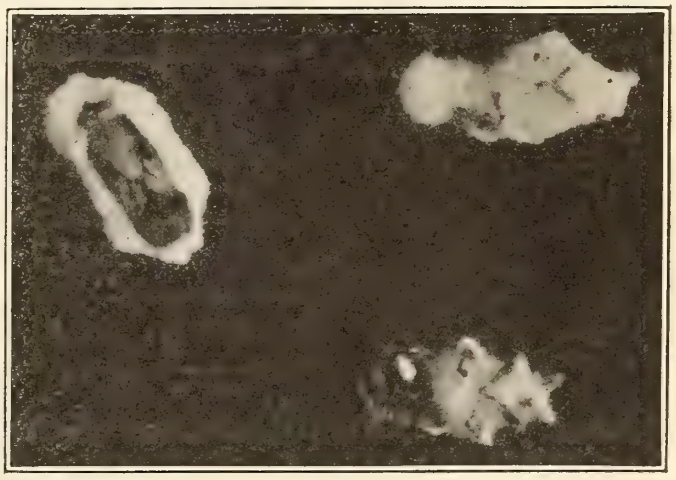

FIG. 15.—The chinch bug: Adults covered with "white fungus" (*Sporotrichum globuliferum*). Enlarged. (Original.)

EXPERIMENTS WITH DEAD CHINCH BUGS.—To determine whether or not *Sporotrichum globuliferum* would make its entire growth upon the dead bodies of chinch bugs, a large number of live bugs, collected from tufts of *Andropogon scoparius*, and which died while confined in a vial, were inoculated artificially and their bodies placed on moist blotting paper. The results of these artificial inoculations compared with their checks are here given.

Inoculation experiments with dead bugs.

Artificially inoculated.			Checks.		
Number bugs used.	Number developing fungus.	Per cent which developed fungus.	Number bugs used.	Number developing fungus.	Per cent which developed fungus.
25	5	20	100	2	2
25	1	4	200	2	1
25	5	20	25	0	.....
25	4	16	25	2	8
40	5	12	25	0	.....
			40	0	.....
140	20	14.28	415	6	1.45

From this table it is seen that while the check cages gave but 1.45 per cent developing the fungus, this percentage was raised to 14.28 when the bugs were artificially inoculated.

Some live and apparently healthy bugs were then killed mechanically by piercing them with a sharp needle, their bodies then being inoculated with the fungus and placed on moist blotting paper.

Inoculation experiments with bugs killed mechanically.

Artificially inoculated.		
Number bugs used.	Number developing fungus.	Per cent which developed fungus.
25 35 25	4 3 3	16 8.57 12
85	10	11.76
Check.		
50	0	0

Others were killed with fumes of chloroform, allowed to dry overnight, then washed in distilled water, and treated as in the preceding experiment.

Inoculation experiments with bugs killed with fumes of chloroform.

Artificially inoculated.		
Number bugs used.	Number developing fungus.	Per cent which developed fungus.
20 25 20	6 5 6	30 20 30
65	17	26.15
Check.		
200	0	0

From these experiments with dead bugs it was found that a small percentage of them could be made to produce *Sporotrichum globuliferum* after inoculation, with every indication that the fungus made its entire growth on their dead bodies.

EXPERIMENTS WITH LIVE CHINCH BUGS.—The cages used in these experiments consisted of a series of small flowerpots containing growing wheat, over each of which was placed a glass cylinder. Into

these cages the living chinch bugs were placed and cheesecloth stretched over the top to prevent their escape. All of the cages were kept on a table in the office, which was heated day and night, and were kept well moistened to promote the rapid development of the fungus. The live chinch bugs which had been dusted with the spores of the fungus were then placed in these cages and the results compared with check cages into which were placed live chinch bugs not previously inoculated. Most of the bugs were provided with plenty of food. Some, however, were placed in a cage containing no food to see if the rate of mortality and appearance of the fungus were to any extent dependent upon the food supply. These experiments are here given, with a record of each cage and its check.

Experiments with living chinch bugs.

CAGES CONTAINING PLENTY OF FOOD.

Cage No.	Number bugs used.	Treatment given.	Number of days experiment continued.	Number of bugs which died.	Number upon which visible fungus appeared.
a 63	25	Inoculated	14	11	7
a 62	40	Check	14	0	0
b 63	15	After 14 days transferred from 62*a* to 63*a*	24	15	11
b 62	18	Taken from 62*a* and inoculated	24	17	7
80	9	Taken from 63*a* and placed in cage free from fungus.	24	0	0
82	25	Inoculated	22	18	4
83	33	Check	22	4	0
90	25	....do	31	20	7
89	25	....do	31	4	0
93	25	....do	35	20	1
92	30	....do	39	4	0
108	25	....do	30	17	11
108*a*	25	....do	30	5	0

CAGES CONTAINING NO FOOD.

120	29	Inoculated	18	27	21
122	25	Check	18	5	0

The fungus always appeared about the third day after the death of the chinch bug, and in no case did it appear sooner than six days after inoculation, the bugs gradually dying and some remaining alive 35 days. Living bugs removed from cage 63, where the bugs were dying and fungus developing, did not die when removed to another cage away from all infection, even though the moisture conditions were about the same. However, all of those remaining in cage 63 died and afterwards became covered with the fungus. This indicates that the rate of mortality can be checked if the bugs are removed from the presence of the fungus.

As between the inoculation and check cages there was a marked difference observed in the rate of mortality, for which no cause other than Sporotrichum seemed to be responsible, as the death rate was always greatest in the inoculated cages. The greatest mortality and

most rapid development of the fungus appeared in cages where the bugs had little or no food. In the stock cages only a very small supply of the fungus could be secured until the food was removed, when it soon appeared abundantly upon their dead bodies lying on the soil.

Conclusions.—From these experiments it is apparent that *Sporotrichum globuliferum* will to a certain extent develop entirely upon the dead bodies of adult chinch bugs. However, the fungus was easily secured in the cages containing living bugs artificially inoculated, particularly when the bugs in these cages were given insufficient food supply.

The indications were also that this fungus is communicable to living chinch bugs, but is evidently not very effective in causing their death unless the bugs possess weakened vitality. This being the case, it would be most effective in nature against old spent adults which have laid their eggs and are comparatively harmless, and it is upon these bugs that the fungus always appeared in greatest abundance, as borne out by field observations during the past three years.

For this reason, as well as its dependence upon favorable weather conditions, its practical efficiency is very questionable; and since it is unable under favorable conditions of moisture and temperature to rapidly exterminate healthy bugs confined in a cage in the laboratory, little dependence can be put upon it to be used against the insects in the field when favorable moisture conditions are so apt to be lacking.

SUMMARY.

Injuries due to the chinch bug west of the Mississippi River are chiefly confined to the States east of the Rocky Mountains where wheat and corn are extensively grown, the most serious outbreaks during 1909 and 1910 occurring in southern Kansas and northern Oklahoma.

There are two generations each year, one during the spring, which attacks the wheat and corn, and one during the summer, which develops on the corn and hibernates. These last pass the winter as adults, and in the States west of the Mississippi River prefer for hibernation the dense clumps of red sedge grass in which they collect in the fall. Very few survive the winter in fallen ears or stalks of corn during severe cold winters, but may survive a mild winter. They fly from the sedge grass to fields of wheat during the first warm days of spring, where the eggs are deposited, and the young hatching therefrom feed with the adults upon the wheat until it has ripened, when they all march in a body to the nearest cornfield. The young become mature on the corn and lay eggs from which hatch the bugs that winter over as above stated. Weather conditions have much to do with the

numbers that reach maturity, many young being killed during a period of wet weather attended by hard dashing rains. Dry weather is most favorable to their development in abundance. The injury to wheat and corn is often severe, sometimes resulting in almost complete destruction of the latter crop after serious injury to the former.

During the severe winter of 1909 and 1910 about 20 per cent of the bugs died normally in the clumps of red sedge grass, where they hibernate.

Experiments in Kansas made during the winter of 1909–10 showed that as high as 75 per cent of the hibernating chinch bugs could be killed by burning this grass. The best time to burn is in the fall, when the grass is as dry as possible. It is not necessary that the flame come in actual contact with the bugs.

The effectiveness of the burning is almost entirely dependent upon the cooperation of the farmers in infested localities. Neglect to destroy chinch bugs collected in these grasses will often result in serious injury, if not indeed a complete destruction of wheat, corn, cane, and kafir.

Next to burning, the dust and coal-tar barriers are the most effective remedies, and should be used while the bugs are migrating from wheat to corn. These barriers must be properly made, and demand constant attention to be of any value.

Many bugs can be killed while massed on the first rows of corn by applying a torch or spraying with kerosene emulsion or proprietary spraying materials.

Plowing under infested crops is not recommended unless the work is done very thoroughly and followed by a crop not susceptible to chinch-bug attack.

Barriers made of piles of green corn are of no value, and are not recommended.

The "white fungus," can not be depended upon to exterminate the chinch bugs. This fungus is very dependent upon moist weather conditions for its rapid development and diffusion. It can usually be secured by collecting live or dead chinch bugs from the sedge grass, and placing them under proper conditions of temperature and moisture. This fungus has many host insects, and is generally present where chinch bugs are found in destructive numbers.

Laboratory experiments show that this fungus is present in greatest abundance among old spent adults, or those bugs that are in a weakened condition. Also that it will grow upon dead bugs. This will partially account for the fact that the time of its greatest abundance in the fields occurs after the hibernating bugs have laid their eggs and are dying normally. These bugs have performed their mission of laying eggs, and are comparatively harmless.

Many bugs lived for weeks, and even months, in confinement in the presence of the fungus under conditions favorable for its development.

Attempts at artificial introductions of the fungus in the fields have so frequently resulted in complete failures that this method is not recommended. Vastly more may be accomplished by applying the same amount of time and labor to the application of practical, successful remedies.

PAPERS ON CEREAL AND FORAGE INSECTS.

THE SO-CALLED "CURLEW BUG."

(*Sphenophorus callosus* Oliv.)

By F. M. Webster,
In Charge of Cereal and Forage Insect Investigations.

INTRODUCTION.

The so-called "curlew bug" (*Sphenophorus callosus* Oliv.) (fig. 16) is allied to the maize billbug, *Sphenophorus maidis* Chittn., the subject of Part II of this bulletin. It is commonly known in the Carolinas as the curlew bug, sometimes as the "klew" or "clewbug," and the "kloobug," all probably contractions of "curlew bug." The curlew is a shore bird, having a long, curved bill, while the insect, *Sphenophorus callosus*, which is provided with a long, curved snout, is found plentifully under rubbish along the shores of sounds and rivers, especially those of North Carolina. Intelligent fishermen, who are familiar with it, claim that it is often found clinging to their fish nets spread in Albemarle Sound.

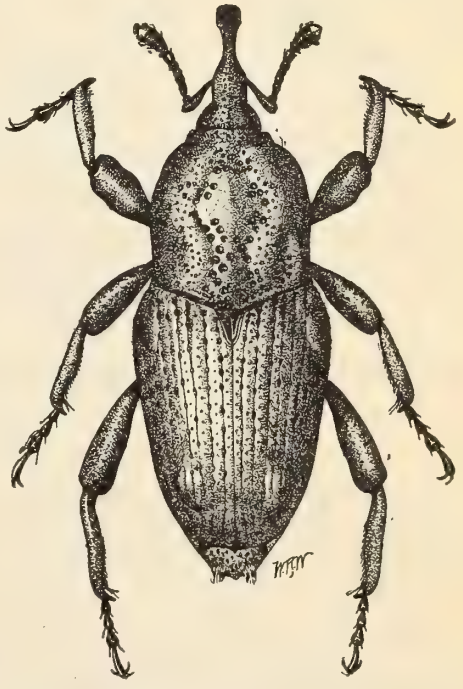

Fig. 16.—The "curlew bug" (*Sphenophorus callosus*): Adult. Four times natural size. (Original.)

The information herein given, in so far as it is original, has been accumulating for a number of years, some of the facts having been taken from the general correspondence of the bureau and others from the results of more or less fragmentary and more recent studies by several assistants engaged in the investigations of cereal and forage insects. While not complete in all of the scientific details, so much of this information is of economic value to the farmer, pointing out to him a practical method of prevention, and will also prove of assistance to station and State entomologists who may desire to study the pest in their own States, that it seems an injustice to withhold publication longer with the object of securing details of

perhaps minor importance. The species was studied to some extent in Illinois several years ago by Dr. S. A. Forbes, State entomologist of Illinois, and his assistants, the results obtained by him being published later by Dr. Forbes under the name *Sphenophorus cariosus* Oliv. Information from that source is also embodied herein.

The author does not himself assume credit or responsibility, except where indicated in the text. Where so many individual investigators have contributed results of observations and studies, it becomes the duty of some one to act as spokesman and put the matter in shape for publication, and this duty the author has endeavored to fulfill.

In his paper relating to this and other species of the genus Dr. F. H. Chittenden,[1] of the Bureau of Entomology, came to the conclusion that *S. sculptilis* Horn is a synonym of *S. callosus* and that *S. sculptilis* Uhler is a synonym of *S. cariosus* Oliv.; also that in many cases specimens received by him showed that references to either of these three species related properly to *S. callosus*. It is upon these conclusions that many of the facts herein given are based.

HISTORY OF THE SPECIES.

The insect was first described by Olivier in 1807, from "Carolina," as *Calandra callosa*.[2] This locality, now somewhat vague, will, as shown in figure 17, apply almost equally well to both this species and *S. maidis*.

While it does not seem possible that this particular species of insect could have existed all of these years in that section of the country—one of the earliest settled, and therefore one of the first to be brought under cultivation—without doing injury to corn and rice, yet as a matter of fact over half a century did elapse before proof of its ravages, accompanied by specimens of the beetles, were in the possession of the Department of Agriculture.

BUREAU NOTES.

June 1, 1880, specimens of the beetle were received from Mr. E. T. Stackhouse, of Marion, S. C., who accused them of damaging young growing corn in his neighborhood.

May 27, 1884, a report was received from Prof. J. A. Holmes, of Chapel Hill, N. C., that this species was injurious to corn near Bayboro, N. C., where it is known as "kaloo bug"; also that the belief was prevalent there that the "insect winters in the rice stubble."

This species, specimens of which were kindly loaned Dr. Chittenden for identification by Messrs. Forbes and Hart, is recorded in the published notes of the State entomologist of Illinois as injuring corn at

[1] Proc. Ent. Soc. Wash., vol. 7, No. 4, pp. 166–182, 1906.
[2] Hist. Nat. des Ins., vol. 5, p. 92, pl. 27, fig. 416, 1807.

Pittsfield, S. C., June 4, 1888. The beetles when received were ovipositing in the box in which they were sent. The species was also found attacking young corn May 1, 1891, the beetle gnawing a large cavity in the stalk just below the ground. "When placed in a breeding cage the beetle made its way into the seed kernel of the stalk."

Brief mention has already been made of its occurrence in Illinois by Dr. Forbes in different papers.[1] It is obvious, as determined by Chittenden, that this entire account of *Sphenophorus cariosus* refers in reality to *callosus*. The illustration given in the publication first cited is of the latter species, as is also the description, and it should be further stated that the occurrence of *S. cariosus* in Illinois is doubtful.

June 10, 1889, Prof. A. J. Cook also reported injury to corn in North Carolina, though the source of his information is not clear.

July 20, 1893, Mr. S. L. Willard, Washington, N. C., wrote that this billbug, called "curlew bug" in that vicinity, was doing considerable damage to the corn crop. Rice also was injured, and it was stated that the insects had been noticed at least 8 years (or since 1886) in that neighborhood. The beetles were also operating in chufa (*Cyperus esculentus*), and some farmers had abandoned rice growing on account of the ravages of this pest.

July 8, 1895, we received word from Mr. B. A. Hallett, Mount Olive, N. C., that this species had completely destroyed the upland rice crop of that section and had greatly injured corn.

During July and August, 1895, Mr. A. N. Caudell reported injury to chufa or yellow nut-grass (*Cyperus esculentus*) at Stillwater, Okla., and August 24 sent pupæ.

May 11, 1896, we received report from Mr. R. J. Redding, Experiment Station, Ga., that this species was attacking fields of young corn in Jefferson County, Ga., by thousands.

May 22, 1897, Mr. Charles B. Guinn reported injury to fields of green corn at Georgia City, Mo.

August, 1898, Dr. Chittenden found, in low bottom-land on the banks of the canal at Glen Echo, Md., the pupa of this species at the roots of witch grass or tumbleweed (*Panicum capillare*). Transformation to imago took place on the 22d.

May 30, 1899, Mr. Edward Markham, jr., Kehukee, Pasquotank County, N. C., wrote that this species had made its appearance in that region, had spread rapidly, and that it was doing so much damage to corn that some crops were being abandoned. It was considered the worst pest of that vicinity—worse than all others combined. It was known locally as the "clue bug," a contraction of curlew bug. Beetles were received from this source as late as July 8.

[1] 16th Rept. St. Ent. Ill., f. 1887 and 1888, pp. 64, 68, 71, 1890. 22d Rept. St. Ent. Ill., f. 1903, pp. 19–21. Bul. 79, Univ. Ill. Agr. Exp. Sta., p. 453, 1902.

August 3, of the same year, Mr. James K. Metcalfe, Silver City, N. Mex., reported beetles as well as larvæ in stalks of corn growing near the Gila River in that vicinity. It was reported that the beetles deposited their eggs in the stalks near the ground; that the grubs ate all the lower part of the stalk and soon destroyed the plant. The beetles destroyed entire fields of corn, working in the usual manner.

August 6, 1900, Mr. G. L. Swindell, Swindell, Hyde County, N. C., reported that this beetle and its larva were injurious to rice—the larva by feeding on the roots and the beetles by attacking the stalks near the ground. The damage done by the beetle to corn in Hyde, Pamlico, Beaufort, and Tyrrell counties could hardly be estimated. In some years it amounted to almost total destruction and was noticeably worse near old rice patches. August 20 this bureau received crowns and roots of the infested rice, as well as larvæ and beetles. In nearly every case there was a cavity in the crown just above the roots, containing the larva and its castings.

During 1901 this species was reported by Mr. Franklin Sherman, jr., Raleigh, N. C., as the cause of general complaint in the eastern part of North Carolina of "billbugs," "klewbugs," "curlew bugs," etc. The species was identified from Elizabeth City and Goldsboro, N. C. Injury was not noticed in the western part of the State. April 23 a report was received from Mr. Robert T. Smith, Grant, Fla., of this species attacking corn, being most troublesome in early March, and infesting the young stalks just below the center, in such a manner that the central leaf often comes out entirely.

Prof. Franklin Sherman, jr.,[1] has given an account of this species with accompanying reports of its injuries to corn in 1902 and 1904 in low, swampy lands in the eastern sections of North Carolina. Injury was also reported by Mr. Sherman in portions of Bladen, Cumberland, Duplin, Moore, and Brunswick counties.

During June and July, 1904, Mr. Thomas J. Clark, Cliff, Grant County, N. Mex., reported billbug damage, and July 27 sent larvæ and imago of this species with the statement that the beetles began operations on young corn as soon as it came up; that they deposited their eggs in the roots; that the larvæ continued feeding in the stalk, and that after the corn began to tassel it would fall over and blight. The stalks, however, seldom developed to that extent before they were killed. He stated that cutworms were nothing to compare with them in their attacks on corn; also that the species was believed to be native to old Mexico and that it had been seen in that vicinity seven or eight years earlier.

June 26, 1906, information was received from Mr. F. B. Hopkins, in charge of the testing gardens at the Arlington Farms, Va., of injury

[1] "Insect Enemies of Corn," Bul. N. C. Dept. Agr., 1905, pp. 19–22.

by the beetle of this species to chufa. The larva was at this time operating in the crown of the plant at the base of the leaves. It was observed that the insect was capable of doing considerable damage even at this early date, as crowns were then found completely honeycombed. On June 28 Mr. I. J. Condit, detailed by Dr. F. H. Chittenden, in charge of Truck Crop and Stored Product Insect Investigations for the purpose of obtaining material, visited the infested locality and obtained numerous specimens of hibernated beetles and larvæ. It was then estimated that the damage would amount to about 20 per cent of the crop. June 30 a larva was found nearly grown. Eggs were also obtained at that time and until the end of the first week of August. Search was made for the natural food of the insects, and this was found in Frank's sedge (*Carex frankii*).

May 22, 1907, Mr. R. I. Smith sent this species from Atlanta, Ga., with the statement that these billbugs were reported as quite abundant and doing great damage to corn at Statesboro, Ga. They had been present at the date of that writing for about three weeks.

DISTRIBUTION.

As will be observed by consulting the accompanying map (fig. 17) this species covers a wider range than *Sphenophorus maidis*. It seems to center in point of abundance in eastern North Carolina, extend-

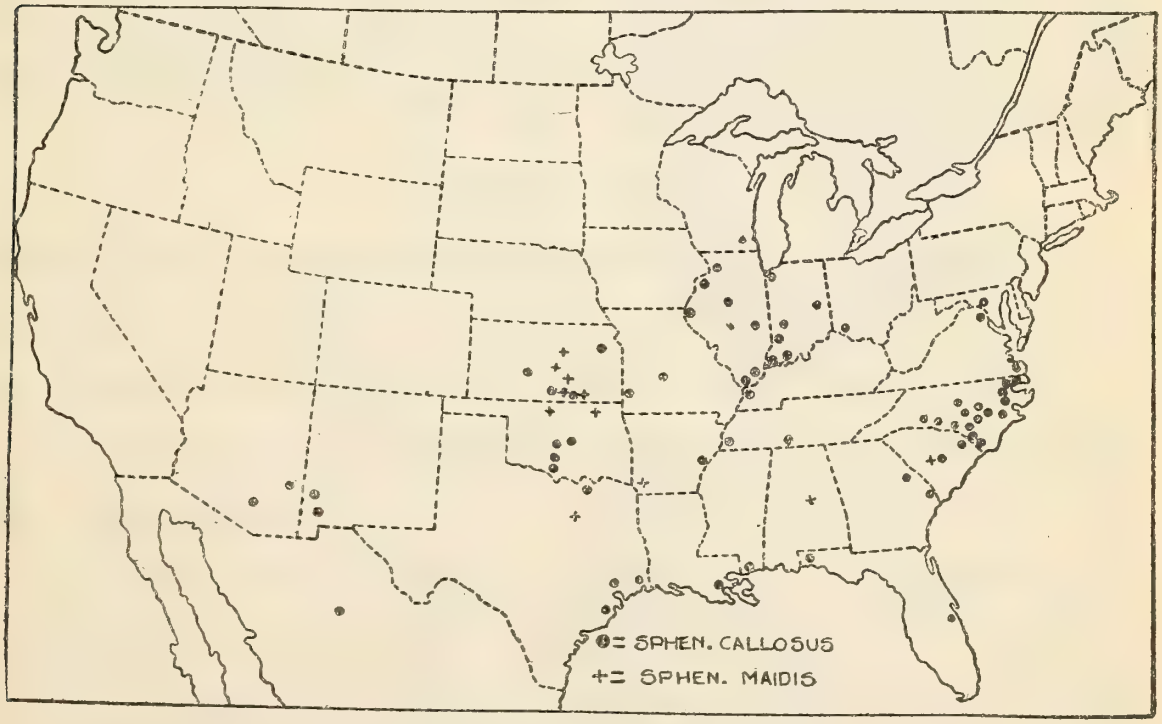

FIG. 17.—Map showing distribution of the "curlew bug" (*Sphenophorus callosus*) and the maize billbug (*Sphenophorus maidis*). (Original.)

ing southward to southern Florida, northward to Maryland, thence northwest to northwestern Illinois, southwest to extreme southeastern Arizona and northern Mexico, and eastward to the Gulf coast.

It is essentially a lowland form, as its food plants clearly indicate, and will therefore especially interest the farmer whose fields are of bottom, swamp, or other low-lying lands.

The following are the localities from which the species has been received:

Arizona: Tucson (Wickham), near Duncan (Cockerell). *Arkansas:* Helena (L. E. Howard). *Florida:* McLellan (W. H. Gill), Grant (Robt. T. Smith). *Georgia:* Jefferson County (R. J. Redding), Statesboro (R. I. Smith). *Illinois:* From Pekin to Cairo, Savanna, Urbana, Metropolis (Forbes), Warsaw (Dr. Shafer), Rock Island (Det. Chittenden). *Indiana:* Lake, Vigo, Posey, Perry, Putnam, and Blackford counties (W. S. Blatchley). *Kansas:* Great Bend, Arkansas City (T. H. Parks), Wellington (Kelly and Parks), Douglas County (Det. Chittenden). *Kentucky:* Opposite Cairo, Ill. (Forbes). *Louisiana:* New Orleans (H. Soltau). *Maryland:* Glen Echo (Det. Chittenden). *Mississippi:* Gulf View (Det. Chittenden). *Missouri:* Georgia (Chas. B. Guinn), Atoka (Det. Chittenden). *New Mexico:* Cliff (T. J. Clark), Silver City (Jas. K. Metcalfe). *North Carolina:* Edenton (J. W. Mason), Elizabeth City (J. P. Overman), Hertford (W. T. Shannonhouse, Mrs. S. D. Jordan), Pineview (W. Barnett), Pyreway (Maj. Gore), Bayboro, Chapel Hill (J. A. Holmes), Washington (S. L. Willard), Mount Olive (B. A. Hallett), Kehukee (Edw. Markham), West Raleigh, Proctorville, Braswell (R. I. Smith), and Hyde, Pamlico, Beaufort, and Tyrrell counties; Swindell (G. L. Swindell), Bladen, Cumberland, Duplin, Moore, and Brunswick counties (Franklin Sherman). *Ohio:* Cincinnati and vicinity (Chas. Dury). *Oklahoma:* Stillwater (A. N. Caudell, C. E. Sanborn), Duncan, Anadarko, Pocasset, Hastings, Cement, Rush Springs, and Chickasha (A. L. Lovett), Duncan, Chickasha (T. D. Urbahns), Marlow (J. F. Davidson), Oklahoma City (T. H. Parks). *South Carolina:* Marion (E. T. Stackhouse), Pittsfield (Forbes and Hart), Rimini (C. R. F. Baker). *Tennessee:* Appleton (P. Cox, Geo. G. Ainslie), Memphis (H. Soltau). *Texas:* Whitesboro (E. O. G. Kelly), Wallisville (W. L. McAtee), Alligator Head (J. D. Mitchell). *Virginia:* Norfolk (Popenoe), Arlington (F. B. Hopkins). *Mexico:* (Prof. Herrera).

FOOD PLANTS.

Dr. Forbes gives *Cyperus strigosus* as the natural food plant, in the roots of which it develops in Illinois. Mr. T. D. Urbahns found it developing in *Tripsacum dactyloides* at Plano, Tex., in July, 1909. At Appleton, Tenn., July 14, 1911, Mr. Geo. G. Ainslie found the infested fields in part grown up with weeds and a swamp Carex (*C. vulpinoidea*), but he was unable to find the beetle actually developing therein. (See Pl. IX, figs. 1, 2.) Mr. A. N. Caudell reported the larvæ injuring the roots of yellow nut grass (*Cyperus esculentus*) at Stillwater, Okla., in 1895. Dr. Chittenden reared the adult from a pupa found in the roots of *Panicum capillare* growing in low bottom lands along the canal near Glen Echo, Md., in August, 1897. Mr. I. J. Condit found it breeding in Frank's sedge (*Carex frankii*) growing on the department farm at Arlington, Va. In Florida the insect develops from egg to adult in *Cyperus rotundatus*, while farther north, in the Carolinas, the common food plant is the "chufa" (*Cyperus esculentus*). To such a degree is this true in the latter locality that the insect is supposed by farmers to have been introduced with that

plant. Quite in accord with the foregoing, Mr. J. G. Sanders reared adults March 30, and again April 25, 1908, from *Cyperus exaltatus*, introduced from Egypt and growing on the department farm at Arlington, Va.

The cultivated food plants are corn, rice, and peanuts, in importance according to the order given.

DESCRIPTION AND LIFE HISTORY.

THE EGG.

(Fig. 18.)

The egg appears to have been first observed by Mr. A. N. Caudell, who noted the female ovipositing at Stillwater, Okla., July 18, 1895. The egg was described as white, 1.5 mm. long and half as wide, oblong-oval in shape. Mr. E. O. G. Kelly, who studied the species carefully at Wellington, Kans., found eggs deposited June 17, 1911, to be "white," 1.5 mm. long, one-third as wide, and elliptical in form.

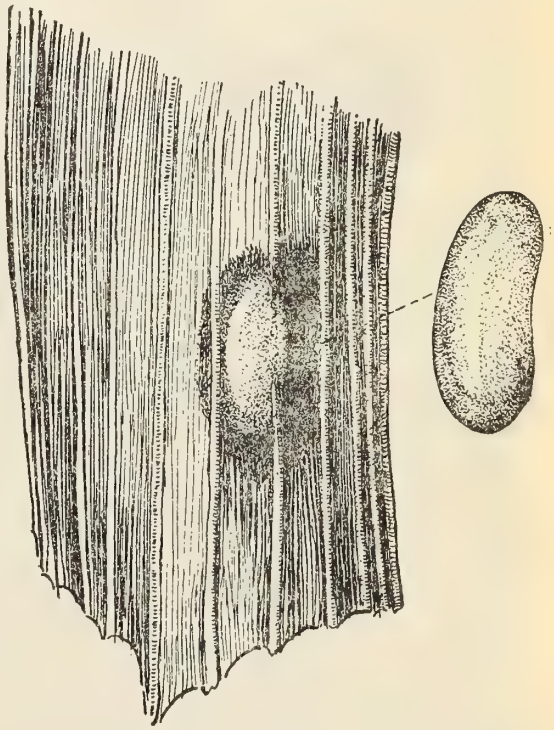

FIG. 18.—The "curlew bug": Egg as placed in stem of young corn plant. Greatly enlarged. (Original.)

Dr. Chittenden described the egg as found at Arlington, Va., as considerably larger, measuring 2.2 to 2.3 mm. in length and only 0.8 to 0.9 mm. in diameter. The outline is subreniform-elliptical, one side having a tendency to straightness along the greater portion of its length. The color is dull, slightly yellowish white. The surface is nearly smooth, with faint reticulation showing in very limited areas. The variation in size of the egg has also been observed by Mr. R. I. Smith, in North Carolina.

Mr. Kelly, in his studies, found eggs from June 16 to September 11, a period of nearly 3 months. The egg period varied from 4 to 6 days in June, in July 5, and from 6 to 8 days in September. In one case 58 eggs were secured from one female, and there was a possibility that she might exceed this number.

Mr. Vernon King and the author found ovipositing adults and half-grown larvæ on Harveys Neck, about 15 miles southeast of Hertford, N. C., on June 20, 1911. This would indicate that oviposition was in progress about June 1. Mr. Jas. A. Hyslop, of this bureau, and Mr. R. I. Smith of the North Carolina Agricultural

Experiment Station, found pupæ in the same locality November 4. If we allow 8 days as the egg period and 37 to 41 days as the larval period, as determined by Mr. Kelly in Kansas, the eggs, judging from the records just mentioned, are deposited in North Carolina from about June 1 to September 20, or during a period of approximately 4 months. Mr. I. J. Condit found a nearly full-grown larva at Arlington, Va., June 30, 1906, which confirms in a general way the preceding observations.

THE LARVA.

(Fig. 19.)

Quite naturally the larva of this species closely resembles that of *Sphenophorus maidis*. The principal differences are brought out in the illustration of *S. callosus*. The head (fig. 19,*b*), is more slender, especially toward the vertex, the area between the Y sutures is nearly smooth and quite different in outline from that of *S. maidis* (fig. 19, *c*) drawn on the same scale. In this latter species the space is shallowly sculptured, with the sutures more sinuate. The larvæ of both species vary greatly in size, and it is doubtful if in this respect they differ materially from each other.

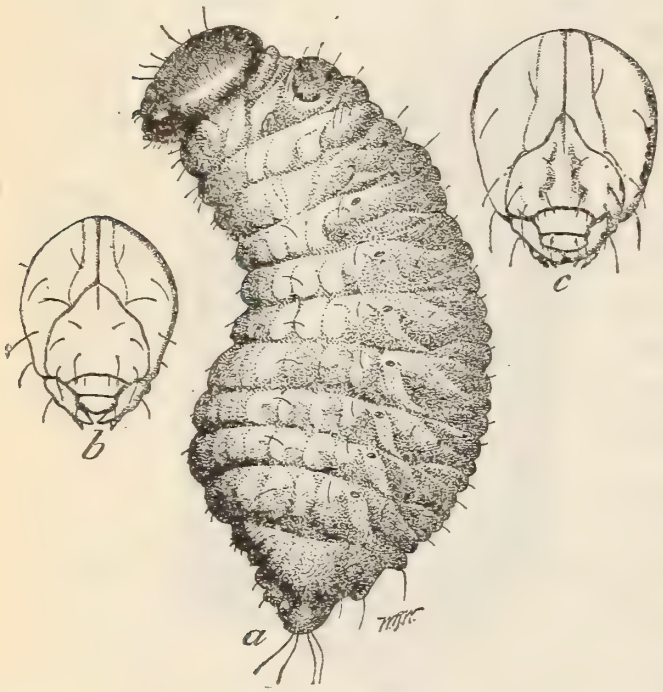

FIG. 19.—*a*, Larva of the "curlew bug" (*Sphenophorus callosus*); *b*, head of same; *c*, head of larva of the maize billbug (*Sphenophorus maidis*). Enlarged. (Original.)

Mr. Caudell found the larvæ among the matted roots, where they form cells and where they are frequently seen completely embedded in the chufa. These they hollow out, leaving only the hull. They are sometimes so numerous that frequently as many as a dozen can be taken in a single bunch of roots.

Mr. I. J. Condit, on October 8, found the larvæ in chufa at Arlington Farms, Va., usually from half an inch to an inch below the surface of the ground. They seemed quite capable of subsisting upon the dead, perfectly brown, and nearly rotten substance of the leaves, stems, and crowns of the plant, but they also perforated the roots.

Mr. F. B. Hopkins observed, on June 26, also at the Arlington Farms, Va., that the larvæ were operating in the crown of this same plant, *Carex frankii*.

Mr. G. L. Swindell, in a communication dated August 6, 1900, states that at Swindell, N. C., the larvæ injured the roots of rice by

THE "CURLEW BUG."

The portion of the Shannonhouse cornfield, Hertford, N. C., on which corn was grown in 1910; totally destroyed by the "curlew bug" *Sphenophorus callosus*, in 1911. (Original.)

THE "CURLEW BUG."

The portion of the Shannonhouse cornfield that was devoted to cotton in 1910; planted to corn in 1911 and uninjured by the "curlew bug." (Original.)

THE "CURLEW BUG."

The dividing line in the Shannonhouse cornfield in 1911 between the portion (to the left of the man standing in the center) devoted to cotton in 1910 and the portion (to the right) where corn was grown in 1910. Note how exactly this corresponds, in point of damage by the "curlew bug," with the nature of the previous crop. (Original.)

feeding thereon. Later, roots sent to the bureau by Mr. Swindell contained larvæ in both the crowns and roots. In nearly every case there was a cavity containing a larva in the crown of the plant just above the roots.

Mr. S. L. Willard, Washington, N. C., under date of July 20, 1893, complained also of injury to rice, stating that the depredations had been observed in his neighborhood since 1886.

Under date of July, 1895, Mr. B. A. Hallet, of Mount Olive, N. C., complained that the insect had completely destroyed the upland rice crop of that section.

In August, 1910, Mr. J. W. Mason, of Edenton, N. C., through Representative J. H. Small, stated that the insect had attacked both corn and peanuts in his neighborhood, killing corn and seriously injuring peanuts.

Mr. R. I. Smith, of the North Carolina Agricultural Experiment Station, states that where rice is grown this grain appears to be its favorite food, as the insect is ten times more abundant in rice fields than in cornfields. The eggs are placed in the corn plant above the roots, as shown in figure 21, *b*. The larvæ work downward, eventually pupating at the lower end of the root, as shown in figure 21, *c*.

In nearly all of our records of injuries by this species, attention is called to the fact that its attacks are upon low or swampy land. The very nature of its food plants would indicate that the natural habitat of this species is in low or swampy lands. In a great many cases such lands are either subject to overflow or the plants are more or less submerged in water for considerable periods of time. While the insect is not aquatic, it most certainly is capable of living and developing on submerged plants without suffering material inconvenience therefrom. In the cornfields they are often found working several inches below the surface of soil thoroughly saturated with water. Farther on, it will be noted that the adult can also live submerged in water without apparent inconvenience.

INJURIES TO CORN BY LARVÆ.

While, as will be shown, corn is injured both by adults and larvæ, attacks by the latter are by far the most fatal to the plant. Good illustrations of a serious attack from a larva of this species are shown in Plates VI, VII, and VIII, from photographs of a field belonging to the Messrs. Shannonhouse, on Harveys Neck, N. C., along the shore of Albemarle Sound. While it is probably true that the insect is much more abundant in rice fields, it must be borne in mind that the area of rice culture is very small compared with that of corn. While local injuries to rice may be very severe, nevertheless the greatest losses from attacks of this insect most certainly fall upon corn growers, especially those whose fields are on low or bottom lands. As

illustrating this point, as well as the severity of attack, Mr. Swindell, who has been previously quoted, stated that in some years the loss amounted to almost total destruction. Mr. R. I. Smith, under date of May 22, 1907, stated that the species was doing great damage to corn at Statesboro, Ga. Under date of May 30, 1899, Mr. Edward Markham, Kehukee, N. C., complained that the insect was doing so much damage to corn in his neighborhood that in some instances the crop was being abandoned. In his estimation it was the worst insect pest observed in his community. Under date of August 3, of the same year, Mr. James K. Metcalf, Silver City, N. Mex., complained that the insects were destroying entire fields of corn, working in this same manner. At Arkansas City, Kans., June 22, 1910, Mr. T. H. Parks, of this bureau, found the species exceedingly abundant in fields of young corn growing along the Arkansas River. Mr. T. J. Clark, sr., of Cliff, N. Mex., under date of June 25, 1904, states that the larvæ are more destructive than cutworms. In his opinion the species is a native of old Mexico and had not been observed in his locality until about eight years previous. Mr. T. D. Urbahns, of this bureau, found that corn about Duncan, Okla., during June 18 and 19, 1909, had suffered very severely. In one case about 20 acres of lowland in the heart of a large field had been entirely destroyed. It had been replanted, but the second planting was also badly damaged. In another field an area, also of about 20 acres, in the heart of a still larger field had been completely destroyed. This land was wet and had been flooded during the previous summer. In a field near Comanche, Okla., consisting of about 100 acres of bottom land, Mr. Urbahns found that the crop had been very severely damaged, some of it having been twice replanted. This land had also been flooded the previous year. A field of about 60 acres in this same neighborhood, examined June 19, had been entirely destroyed. At Great Bend, Kans., July 7, 1910, Mr. Parks found that a field of 6 acres of corn had been damaged about 20 per cent by these insects. Under date of May 17, 1909, Mr. J. F. Davidson, of Marlow, Okla., complained that the insect had completely destroyed 100 acres of young corn on his farm. Some of this ground had been replanted a third time, with discouraging prospects of his being able to secure a crop of corn. He further states:

> My land is all bottom and valley and adjacent to Little Beaver Creek, a stream 50 feet wide. The heavy floods of last spring caused this creek to overflow its banks and the water spread out over all the bottom land, inundating thousands of acres and destroying the growing crops; 40 acres of my land was thus under water seven different times. I assume the result is the billbug and its depredations this spring on all bottom lands, which are the best corn lands in this section of Oklahoma. Thousands of acres have already been completely destroyed by this pest, and farmers are now busy replanting, with slight hopes of securing a stand that will justify cultivation.

The larva on first hatching is, of course, very small, although, as the eggs increase in size after being deposited in the plants, the size of the larva will considerably exceed that of the newly deposited egg.

It burrows its way downward through the center of the lower stem into the main root or taproot and, unless this is entirely eaten away, probably finishes its development there. Although we have not observed it, it seems quite likely that under certain conditions it may transform to the pupa in the earth outside of the plant.

Studies carried out by Mr. Kelly at Wellington, Kans., have shown that the larval stage may occupy from 37 to 41 days—the latter period in most of his experiences.

THE PUPA.

(Fig. 20.)

Pupation in the crowns of chufa takes place normally in cocoons formed of dried castings, but in cases where the crowns have been much eaten away, the larva before transforming evidently falls out and pupates in the earth nearby, generally within an inch or less of the crown. In the earth a cell is made by the larva, which turns round and round, thus forming quite a distinct earthen cocoon. In one instance noted by Mr. Caudell, a pupal case or cocoon was found on chufa about 2 inches above the ground, indicating that the larva had floated to the surface of the water, the plants being submerged at the time.

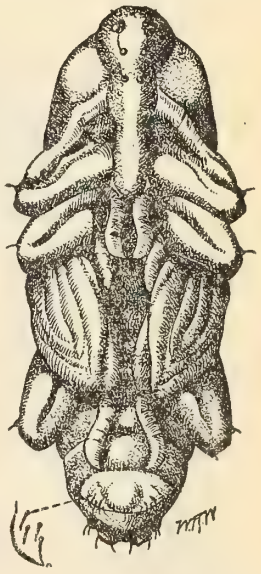

FIG. 20.—The "curlew bug:" Pupa. Greatly enlarged. (Original.)

In corn plants pupation takes place in the larval chambers as shown in figure 21, *c*.

A larva noted by Chittenden transformed to pupa August 22, and the beetles issued September 1, the period of the pupal stage having been about 9½ days. As the weather during this time was considerably over 80° F., and quite humid, 9 days is probably the minimum pupal period for this species.

Of a number reared by Mr. Kelly at Wellington, Kans., during August, 1910, one pupated in 9 days, while three others pupated in 13 days.

THE ADULT.

(Fig. 16.)

This species was first described by Olivier in 1807.[1] In his paper entitled "New species of Sphenophorus with notes on described forms," [2] Dr. Chittenden has fully discussed this species as follows:

> This species was united by LeConte [3] and Horn with *cariosus* Ol., but wrongly so, as I shall attempt to prove. Olivier's description reads in substance as follows:
>
> Body black with dark cinereous coating. Antennae brownish black, shining, cinereous at apex. Rostrum black, dark cinereous at base. Thorax uneven, "and

[1] Calandra callosa Olivier, Hist. Nat. des Ins., vol. 5, p. 92, pl. 28, fig. 416, 1807.

[2] Proc. Ent. Soc. Wash., vol. 7, No. 4, pp. 176–177, Mar. 9, 1906.

[3] Rhynch. N. A., p. 425.

one sees on the superior portion an elevation in the form of a cross, feebly marked." Elytra uneven, feebly variolate, marked toward the apex with a callous point, nearly spinose, blackish, shining.

Olivier's illustration is imperfect in that it is very crude, showing neither punctuation nor sculpture and the general impression is that of a shining species, which was certainly not intended. The thorax is a little short, otherwise the form coincides with the species which is figured herewith.

The cinereous base of the rostrum is an important character, as it signifies that a considerable portion of the base is coated while in *cariosus* it is not. The cross-like elevation of the thoracic disc is aptly described as feebly indicated, in fact it requires a little imagination to discern it in many individuals; moreover, it is not shown in Olivier's figure.

Among coleopterists in general the adults of this species are supposed to be covered by a coating, consequent upon the beetles coming in contact with the soil. This supposition is most certainly erroneous, as adults secured by Dr. Chittenden from cocoons and by others of the bureau from the chambers in the roots of corn before they had come in contact with anything excepting the débris with which the chambers are more or less filled, are found to possess this coating.

Specimens secured by Dr. Chittenden are of a rich brown color with velvety surface. It is only when the beetles become somewhat abraded and this coating worn off of the elevations and the shoulders and near the tip of the elytra that the callouses are formed, a character upon which the specific named is based. Strictly speaking, the perfect insect has not been described, and it does not become "*callosus*" until the insect has moved about and rubbed these points bare.

The adults evidently hibernate to some extent in corn in the chamber in which they have developed, but seemingly lower down than in the case of *Sphenophorus maidis*. (See fig. 21, *c*.) They were found very sparingly, by Mr. James A. Hyslop of this bureau and by Mr. R. I. Smith, of the North Carolina Agricultural Experiment Station, occupying this position in the cornfields of Harveys Neck, previously mentioned, on November 1, 1911. The numbers found, however, were far too limited to indicate that this can be true of even the majority, the others probably wintering over either in or near the surface of the ground. This was in the same field where Mr. Walton had fruitlessly searched for them on September 5 and 6.

When we come to take into consideration the fact that the natural coating with which the adults are covered is almost exactly the color of the soil, with which it is, indeed, more or less begrimed, and that the insects on being disturbed will draw up their legs and remain as quiet as if dead, it will be seen that it is exceedingly difficult to detect their presence in or on the surface of the ground, even by an expert who knows exactly for what he is searching. Therefore that careful search should not happen to reveal their presence is not especially to the discredit of those who are engaged in trying to find them.

As will be observed, this method of hibernation is of the greatest importance from an economic standpoint, because hibernation in the lower stalk or roots would bring the inhabitants within reach by pulling up and burning these stalks during the winter or early spring. For data on the larger corn stalk-borer see Circular No. 116 of the Bureau of Entomology, entitled "The Larger Corn Stalk-Borer."

The beetles probably come forth from their hibernation quarters quite early in spring, as soon as the ground has become permanently warm from the spring temperature. Mr. Kelly found them under cornstalks of the previous year at Whitesboro, Tex., April 13, 1910. They evidently feed for a considerable time by puncturing the lower part of the stems of the plants. These punctures are quite different from the egg punctures, and the effect is often not so fatal as that occasioned by the downward burrowing of the larva. These punctures are usually made about or a little below the surface of the ground, the beetle evidently searching for a point where the stem is tender and succulent.

FIG. 21.—The "curlew bug:" *a*, Corn plant attacked by adult insect; *b*, egg as placed in stem of young corn plant, enlarged at left; *c*, pupa and adult in root of corn in chamber eaten out by the larva, slightly reduced. (Original.)

If the punctures are made lower down on the plant, just above the root, the result is a throwing up of a number of tillers or suckers from the roots, the main stem itself having a stalky appearance, with the result that no ears are produced. In this respect the effect produced resembles to a degree that of an attack of the Hessian fly on a young wheat plant in the fall. This unusual development of tillers

or suckers has sometimes been vulgarly termed "frenching," although it must not be understood that all of the difficulties known as "frenching" in corn have been due to the attack of these beetles.

If the puncture made by the beetle for the purpose of securing food has been made higher up the stem, food has been obtained from the unfolded leaves above the crown of the plant. When these leaves finally push forth, the puncture made by the beak of the beetle appears in the shape of transverse rows across the leaves, as illustrated in figure 21, at *a*. Frequently there will be a distorted growth on the stem, having much the appearance of galls or excrescences, as shown also in this figure.

While the damage done by the beetles in feeding is in many cases doubtless severe—if the corn plants are very young at the time of attack they are probably destroyed in this way—generally speaking the greatest damage is probably caused by the larvæ, especially in the East.

Attention has already been called to the fact that the larvæ can apparently live without difficulty for a considerable length of time in the stems of plants that are completely covered by water. This is surprisingly true in the case of the adult insect.

August 4, 1906, Dr. Chittenden collected adults of this species at Arlington, Va., and placed them in a jar of water with a few stalks of grass and chufa. The beetles attached themselves to these stalks under water and remained there. Two of the beetles were removed November 21 of the same year, and although they had been submerged during the entire period they were still "very much alive." Another instance has come to our notice which would indicate that not only can these beetles survive in fresh water, but also in salt water.

Mr. James Overton, a farmer and fisherman residing on the north shore of Albemarle Sound, informed the author that this species was frequently found by him clinging to his fish nets set in the water of the Sound, and that he found them abundantly under the débris along the shore. As Mr. Overton is perfectly familiar with the work of the insect in the cornfields, and was one of the first in his neighborhood to recognize it, there does not appear to be any reasonable doubt of the correctness of his statement. Indeed, farmers living on Harveys Neck are of the opinion that the pest first came to them from the South, having drifted across the Sound from the opposite shore. Mr. Overton, who resided on the southern shores of the Sound before taking up his residence on Harveys Neck, states that the insect was destructively abundant along the southern shore before it was observed in his present neighborhood. Whether this theory of the diffusion of the pest is correct or not, there does not appear to be any good reason why the insect might not drift about in the waters of the

Sound and be carried ashore by the tides. In at least two cases, each involving a different species of Sphenophorus, adults have been found along the sea beach in situations where they must have been submerged at each flow of the tide.

The length of life in the beetle stage is not definitely known, but Dr. Chittenden has observed overwintered adults as late as August 8, thus overlapping the appearance of the new generation of adults.

INJURY BY THE BEETLES.

It is rather difficult to separate out, in the correspondence of the bureau, injuries that have been caused by the adults, or beetles, of this species from those inflicted by the larvæ. That the larvæ are eminently capable of totally destroying young corn is very evident, but the following extract points more or less conclusively to the beetles themselves as being the authors of the injuries inflicted.

Mr. C. R. S. Baker, Rimini, S. C., June 26, 1909, in a communication to the Bureau of Statistics, stated that the beetles were killing young corn by puncturing the stalk to the heart, killing the plant precisely as with the "budworm." This particular field had been highly fertilized with guano and stable manure. Maj. Gore, of Pireway, N. C., May 12, 1910, stated that 30 acres of corn planted on new land had been literally eaten up by the beetles; presumably the new land was either very low or reclaimed swamp. Under date of May 21, 1910, Mr. W. Barnett, of Pireway, N. C., stated that a farmer in his neighborhood had lost half of his crop of corn from attacks of this beetle. Writing from Helena, Ark., June 2, 1911, Mr. L. E. Howard stated that these beetles were killing the corn, mostly young corn, but some as large as waist-high. Writing from McLellan, Fla., May 2, 1909, Mr. W. H. Gill stated that the pest had just made its appearance in Santa Rosa County and attacked young corn about a month old by boring in the stalk underground and killing the center. On June 1, 1910, a complaint was received from Mr. P. Cox, Appleton, Tenn., inclosing specimens of the beetle which he stated were destroying his corn crop and asked for an investigation of the trouble. July 14, Mr. G. G. Ainslie visited the locality and found that Mr. Cox's field consisted of about 40 acres lying in a creek bottom. Farther down the stream were two other fields of corn all of which had been damaged. It seems to be the plan in that particular locality to allow the land to go uncultivated every alternate year. During the season in which the land is idle there springs up a heavy growth of weeds and swamp grass. This particular field was plowed the latter part of March and replowed the last day of April, corn being planted soon after. The first planting came up quickly, but was utterly destroyed. The second planting, the date of which was not obtained, was also practically destroyed, and a little before the middle of June a third

planting was made. On the lower depressions of the field (see Pl. IX, fig. 1), termed "swales" in that neighborhood, the corn from this planting was either small or missing, the size of the stalks being very irregular. In most cases the main stalk was aborted and suckers had been thrown up, sometimes a distance of several inches from tne original plant. The main stalk was either missing altogether or had become so dwarfed and distorted as to be practically worthless. (See Pl. IX, fig. 2.) It lies prostrate on the ground, curled and twisted, being sometimes almost buried in the loose earth, and the beetles were still found attacking the plants.

RECENT INVESTIGATIONS OF THE BUREAU OF ENTOMOLOGY.

Reference has already been made in the proper places to the investigations carried out in Kansas, Oklahoma, and Texas by Messrs. Kelly, Urbahns, and Parks, of the Bureau of Entomology, and in North Carolina by Mr. James A. Hyslop, also an assistant in the bureau. On May 23, 1911, we received a communication from Mrs. S. D. Jordan, Hertford, N. C., accompanied by specimens of these beetles, stating that the insects take possession of and destroy whole fields of corn as soon as it comes up. Many farmers had been obliged that season to plow and plant their corn for the second time. The insects attack the plants by inserting their bill into the stalk near the ground, causing the plants to wilt in a few hours. The trouble had been noticed for several years and appeared to be rapidly on the increase. Apparently, unless some steps were taken for their protection, the farmers in that neighborhood would not be able to raise sufficient corn for their own use. Two days later a communication was received from Mr. William T. Shannonhouse, from the same post office, accompanied by specimens of the bettles. Mr. Shannonhouse complained that these insects attacked the corn from the time it was 3 or 4 inches high until it became 10 inches or a foot in height. Then they were found just below the surface of the ground puncturing the stalk, causing the death of the plant. Mr. Shannonhouse called attention to the fact that where corn had followed cotton crops no damage was apparent, but where the preceding crop had been corn the damage was in many cases very severe, often resulting in a total loss of the crop. In cases where the land had been planted to corn in alternate years, and during the intervening years to some other crop, no difficulty was experienced. The author, together with Mr. Vernon King, visited these fields in company with Mr. Shannonhouse on June 20 and made a careful examination of them. It was found that where cotton had been the previous crop, attack by Sphenophorus was hardly noticeable. Larvæ were abundant, ranging from newly hatched to half-grown, while eggs were being deposited on both small, tender plants, and on larger, more mature

FIG. 1.—VIEW OF CORNFIELD NEAR APPLETON, TENN., SHOWING DAMAGE BY THE "CURLEW BUG." (ORIGINAL.)

FIG. 2.—CORN PLANTS, SHOWING NORMAL PLANT AND THOSE DAMAGED BY THE "CURLEW BUG." (ORIGINAL.)

ones. From one to several eggs were laid on each plant, either just beneath the surface of the soil, slightly above the roots, or from 2 to 3 inches above this point in the stem. Beetles usually rest on stems head downward, often partially hidden by soil around the plant, and frequently with the beak inserted into the tissues of the stem. At the bottom of slits made by the beak, and easily seen with the naked eye, there is often a white, elliptical egg, sometimes with one end transparent. Both males and females were common. On June 22, about 3 miles away across the Perquimans River, on the farm of Mr. R. L. Spivey, Mr. King observed the same work in a small patch of corn planted on spring-plowed land which bore corn the year before. Near Mr. Spivey's farm injury was also done to 3 or 4 acres of corn on the farm of Mr. J. T. Jackson, whose land also bore corn the year before. At this time only a few large plants of the first crop were standing. The land had been replanted, but only sickly plants were produced, as these had been attacked by Sphenophorus and by *Diatræa* sp., the latter of which is locally known as the "budworm." An adjoining patch of corn, planted on soil which bore corn last year, but cut early and the land fall-plowed, was seemingly growing.

On July 25 Mr. W. R. Walton visited the same locality and, in the same fields previously examined by Mr. King and the author, found larvæ, apparently nearly full grown, in the taproots and crowns of the plants. Although no longer feeding, they had not yet transformed to pupæ, nor were they yet in cells formed for pupation. Some of the less seriously injured stalks of corn were from 6 to 8 feet high, with one well-developed ear. No grasses or sedges in which the insect could develop could be found in the neighborhood, although Mr. Walton was told by Mr. Overton that masses of both of these plants, with heavy root-stalks, sometimes drift across Albemarle Sound from the South. Farmers in that neighborhood say the pest began its depredations along the north shore, and express the opinion that the pest came from the South. Later, September 5 and 6, Mr. Walton again visited the same locality to learn the condition of the pest, but although he examined and pulled up about 100 stalks of corn where the pest had been abundant earlier in the season, he could find no trace of it in any stage.

REMEDIAL AND PREVENTIVE MEASURES.

With these insects in full possession of a field, there does not appear to be any thoroughly practical and effective measure for preventing or overcoming their ravages. While throwing up the soil or hilling up the young plants with the cultivator might prevent the beetles themselves from puncturing the stems low enough down to cause the plants to sucker or become distorted, this is by no means assured.

We only know that the higher up the insect punctures the stem the more likely is the attack to result only in the transverse rows of holes across the leaves, as shown in figure 21 at *a*. In any case this ridging or hilling up would only form a possible slight protection against the injurious effects of the feeding of the beetles. Once the larvæ have started to burrow their way downward in the stem there is no way whereby they can be reached by any measure likely to seriously affect them. The beetles can not be trapped by inducing them to hibernate under piles of rubbish prepared for them especially for this purpose, because there is excellent proof that they pass the winter in fields entirely bare of vegetation. Late planting of the crop, as exemplified by repeated replantings, does not offer any encouragement in the way of preventing future injuries. As shown by the observations of Messrs. Walton and Hyslop, very few of the insects hibernate in the roots or old stalks, so that the pulling up and burning of these, as in destroying the larger corn stalk-borer, would not be of much value against this insect. They probably do not hibernate to any extent in their uncultivated food plants.

Fortunately, however, the farmer has within his reach two most practical and efficient measures of prevention. One of these is to entirely exterminate from his fields any of the natural food plants of this species. Indeed, he should by no means attempt to raise a crop of corn while any of this natural vegetation, upon which the insect can subsist, is still in existence. The other measure is to follow corn or rice with some crop upon which this insect can not feed and never to plant corn immediately after corn or rice. On the farms of the Messrs. Shannonhouse most convincing illustrations were afforded of almost complete protection by rotation of crops. While in no case was it possible to find a badly infested field of corn following cotton, there were plenty of illustrations of the disastrous effect of attempting to raise corn during successive years on the same ground.

One field offered such an excellent illustration of this phase of the problem that Mr. William T. Shannonhouse had it photographed, and these photographs are used for illustration in Plates VI to VIII. In 1910 the eastern portion of this field had been devoted to cotton, the western portion to corn. In the year 1911 the entire field was planted with corn; as a result that portion on which corn had been raised the previous year (see Pl. VI) was almost totally destroyed by this insect, while the other portion, where cotton had been grown (see Pl. VII), was almost entirely exempt from attack. In order to show the abruptness with which this injury terminated and the exactness with which this corresponded to the dividing line between the two previous crops, the farmer who had himself cultivated the field in 1910, and was therefore perfectly familiar with it, was induced to stand exactly upon the dividing line between the corn and the

cotton. Plate VIII shows the area where this dividing line between the two crops of the previous year was located and the radical difference in attack by Sphenophorus between the two portions of the field. This field illustrates conclusively both the fact that the beetles winter in the fields where they develop and also that crop rotation is effective in preventing serious injury.

NATURAL ENEMIES.

Mr. W. L. McAtee, of the Biological Survey, has recorded the finding of *Sphenophorus callosus* in the stomach of the nighthawk (*Chordeiles acutipennis texensis*) at Wallaceville, Tex., August 4, 1907. This is the only exact record obtainable of the eating of this species by birds. In addition Dr. Chittenden has placed the following notes at the disposal of the author:

> Among the larvæ of this species in our rearing cages in late August and early September some years ago were some which had died, apparently of fungus attack, although there is a possibility that the fungus attacked the insect while dying or after death.
>
> In another instance, during the last week of August, larvæ of this same species were dying and specimens were referred to Dr. Haven Metcalf, a pathologist in the Bureau of Plant Industry, who stated that they were apparently free from fungi, and that while there was a possibility of the presence of a bacterial disease such presence could not be established at that stage. Examination, however, revealed the fact that the bodies of the larvæ were fairly reeking with nematodes, and it is not impossible that these are the cause of the insect's fatality.

On September 5 and 6 Mr. Walton found, in cornfields in North Carolina where the corn had been destroyed (see Pl. VIII), many exit holes of the predaceous maggots of a robber fly, *Erax lateralis*, between the rows of corn, and it is possible that these may have devoured some of the larvæ of Sphenophorus. Lamphyrid larvæ were noted, both by the author and by Messrs. King and Walton, about the infested hills of corn. Although these are known to be predaceous, none of us was able to catch them in the act of devouring the larvæ of the curlew bug.

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PAPERS ON CEREAL AND FORAGE INSECTS.

THE FALSE WIREWORMS OF THE PACIFIC NORTHWEST.

By James A. Hyslop,
Agent and Expert, Cereal and Forage Insect Investigations.

INTRODUCTION.

Up to within the past five years, except for a few scattering notices, the species of Eleodes have been considered of only incidental, if of any, economic importance. The Tenebrionidæ, to which this genus belongs, are sometimes saprophagous, feeding on dead vegetable matter in the soil, and occasionally on dead animal tissue as well as on stored grain and other food products.

Superficially the larvæ resemble the true wireworms (elaterid larvæ), and on account of this resemblance and the similarity of their

Fig. 22.—The false wireworm, *Eleodes letcheri vandykei:* Adults in characteristic attitudes. Somewhat enlarged. (Original.)

depredations in the grain fields the two are often confused. On closer examination, however, Eleodes larvæ can be easily recognized; the antennæ are rather long and very conspicuously clavate, the body is not flattened, and the forelegs are long and stout. These larvæ can move with great rapidity as compared with true wireworms

The confusion of Eleodes with the true wireworms is unfortunate, as the preventive and remedial measures for the two pests are quite distinct, what is efficient treatment in one case being quite useless in the other.

HISTORICAL.

Among the earliest references to the economic importance of these beetles in this country is a note by Prof. Lawrence Bruner,[1] in which the species *Eleodes tricostata* Say is recorded as attacking cabbage

[1] Bul. 26 (old series), Div. Ent., U. S. Dept. Agr., pp. 11-12, 1892.

plants at Lincoln, Nebr., doing even more damage than the cutworms. It was also said to have attacked other garden crops, but these are not definitely recorded.

In 1895 Prof. C. V. Piper published an article in the Northwest Horticulturalist in which he refers to Eleodes larvæ attacking garden crops.

In 1898 Mr. Theo. Pergande [1] notes having received from McPherson, Kans., two larvæ of a tenebrionid with the statement that they do serious damage to wheat in Salina County, Kans., by attacking the grain when it becomes softened, destroying the germ. From one of these larvæ an adult was reared which proved to be *Eleodes suturalis* Say. In the autumn of 1911 Mr. E. O. G. Kelly, of this office, found the wheat in southern Kansas attacked by an Eleodes larva which may prove to belong to this latter species.

In 1908 Mr. Myron Swenk,[2] assistant State entomologist of Nebraska, reported *Eleodes opaca* Say as doing very serious damage to wheat in Nebraska, in some instances 60 per cent of the seed having been destroyed.

The larvæ were first found by the author in enormous numbers in May, 1909, in a wheat field south of Pullman, Wash. The field was entirely ruined and had to be reseeded, though these depredations were not entirely due to the Eleodes, as a true wireworm, the larvæ of *Corymbites inflatus* Say, was also very numerous.

On May 12 several adult *Eleodes pimelioides* Mann. were found at a depth of about 4 inches below the surface in the field above mentioned, and more were found under boards and rubbish about the fields. Many larvæ were placed in flowerpot rearing cages with wheat as food, and on July 3 a pupa was found in one of these cages. On July 20 an adult *Eleodes pimelioides* emerged. Later examination of several collections very clearly indicates that this species is far the more predominant in the Palouse country.

Other species known to occur in this region are *Eleodes obscura* Say var. *sulcipennis* Mann., *Eleodes hispilabris* Say var. *lævis* Blaisd., *Eleodes extricata* Say, *Eleodes manni* Blaisd., *Eleodes humeralis* Lec., *Eleodes schwarzii* Blaisd., and *Eleodes nigrina* Lec.

In the spring of 1909, on examining an oat field at Govan, Wash., that had been almost completely destroyed, many tenebrionid larvæ, *Eleodes letcheri* Blaisd. var. *vandykei* Blaisd., were found crawling over the surface of the field. They had evidently been forced to leave the ground by a heavy rain which fell the day before. On digging in this field many more larvæ were found about ready to pupate.

In the spring of 1910 the adults were found in enormous numbers on the roadsides in the Big Bend region and in the middle of the

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Bureau of Entomology Notes, No. 8186. [2] Journ. Econ. Ent., vol. 2, p. 332, 1909.

summer they were found under the grain shocks in large numbers. In this region the species in enormous preponderance is *Eleodes letcheri vandykei*. *Eleodes pimelioides*, *Eleodes nigrina*, *Eleodes hispilabris* var. *lævis*, and *Eleodes obscura* var. *sulcipennis* also occur; the first one rarely, the last three quite commonly.

The results of three seasons' work in the Pacific Northwest demonstrate quite conclusively that the false wireworms are among the most destructive insects to recently planted wheat and corn in this region. They rank second only to the true wireworms (elaterid larvæ).

False wireworms are native and not introduced forms; the climatic conditions of the country are, therefore, ideal for their existence. The converting of enormous areas of the scantily verdured sagebrush prairie into wheat ranches has afforded them a new and increased food supply and the destruction of the sage hen, badger, and horned toad has removed their normal foes.

DISTRIBUTION.

The genus Eleodes, to which the beetles treated in this paper belong, is very closely confined to the Upper and Lower Sonoran Zones. These beetles do not fly and are therefore more restricted in their distribution than insects which have a more active means of dissemination. The mass of the species occur in the Southwest, while several occur in the arid and semiarid regions of California, Oregon, Washington, and Idaho. A few species extend into the Carolinian Zone in Kansas, Nebraska, and Iowa, *Eleodes tricostata* having been collected as far east as Independence, Iowa.

Eleodes pimelioides, however, seems to be an exception to this general rule, and is very nearly confined to the northwestern portion of the Transition Zone, only occasionally being found in the Sonoran where this zone merges into the Transition. Specimens have been collected in the very humid coastal region of Washington, as well as in semiarid regions of this State, of Idaho, and of Oregon; in the Rocky Mountains at Helena, Mont., as well as at very nearly sea level on Vancouver Island. The species is predominant in the semiarid Transition of Washington and Idaho, the region commonly known as the Palouse country. The southernmost records of this species are Lake County, Cal.; Elko, Nev.; Wasatch, Utah; and Garland, Colo. It extends east to the middle of Colorado and north to Vancouver, British Columbia.

Eleodes letcheri vandykei has been collected at The Dalles, Oreg., by Messrs. Hubbard and Schwarz. Dr. E. C. Van Dyke has taken this species in Modoc County, Cal., and we have found it to be the predominant species in the Big Bend region of Washington. All of these localities are well within the Upper Sonoran Zone.

Eleodes opaca is apparently confined to the Plains region east of the Rocky Mountains, specimens having been collected in central and eastern Colorado, western Kansas and Oklahoma, northern Texas, all of Nebraska, and southern and eastern South Dakota.

Eleodes suturalis occurs over about the same region as *E. opaca*, with its variety *texana* Lec. extending southward into New Mexico and southern Texas.

THE WORK IN THE BIG BEND REGION OF WASHINGTON.

On May 28, 1909, an oat field at Govan, Wash., was examined. This field had been almost completely destroyed by true wireworms; besides these, many larvæ of *Eleodes letcheri vandykei* were found on the surface of the ground, evidently forced out by the unusually late heavy rains of the preceding day. These latter were by far too few in numbers to have destroyed the oats. Bluebirds (*Sialia mexicana occidentalis*) were noticed feeding in the fields in large numbers on the exposed Eleodes larvæ. Many of the larvæ were also found in the ground at a depth of from 3 to 5 inches, in small spherical cells, wherein they lay in a curled position. These were considerably softer and paler colored than those found in an active condition.

The work in 1910 started early in April when the false wireworms were to be found scatteringly throughout the grain fields, the grain having just sprouted.

Adults were first observed in 1911 on April 17, the day being quite hot, but the weather up to this time having been very cool. The beetles were to be seen at about 3 o'clock in the afternoon in great numbers along all the roadsides, where they were either awkwardly hurrying over the ground or nibbling at the foliage of the very young *Polygonum littorale*, which is very abundant in this region.

Adults of the larger species, *Eleodes obscura sulcipennis*, were usually to be found in or about the burrows of the ground squirrel (*Citellus townsendi*) and the badger.

When disturbed, the species of Eleodes have the ludicrous habit of standing still and elevating the abdomen so that the long axis of the body approaches the perpendicular instead of the nearly horizontal position it normally maintains while walking or at rest. The two beetles to the right in figure 22 are in this attitude. Thus they will remain motionless for several minutes and finally, if they are not further disturbed, they walk off. If one places the finger near the insect, an oily liquid is excreted from the anal aperture, which flows down over the elytra and abdomen. This liquid is pale yellow in color and makes a dark-brown stain; it has a very characteristic, strong, astringent, and offensive odor, and is evidently protective in

function. Mr. Carl F. Gissler [1] describes this secretion and the glands from which it is secreted.

Many pairs were in coitu on the 17th of April, and on the 21st a female that was confined in a pill box laid four eggs. Between the 21st and 23d, when the female died, she laid 10 more eggs, which, however, failed to incubate. Females dissected in the laboratory were found to contain from 92 to 199 eggs. The eggs were found to lie on the ventral side of the abdomen and to extend upward and over part of the viscera, filling all the interstices about the alimentary canal. The eggs were so crowded in the abdomen that they were quite distorted. Anteriorly the eggs were smaller and were fastened to the anterior abdominal sclerite by fine filaments.

The mating season lasted about two weeks, but the adults were in evidence throughout May and June. Well-grown larvæ were also to be found at this time. Many of the adults in the rearing cages, as well as two individuals observed in the field, were seen to burrow into the ground. This is accomplished by digging with the front tibiæ, which are expanded and armed with spines for the purpose, the tarsi being folded back out of the way. The loose dirt is conveyed backward by the middle legs and piled up behind the beetle by the hind legs. When about one-fourth of an inch of dirt has accumulated the beetle backs out of the hole, pushing the earth out with the abdomen, the hind legs assisting in this process by keeping the earth piled behind the abdomen. On examining these burrows two or three eggs were found in each. The burrows are filled with earth after the beetles come out and are from 4 to 8 inches deep.

Rearing cages were established by sinking barrels to the surface level, filling them with earth, and fitting vertically onto the top a galvanized-iron cylinder 10 inches in height and the diameter of the inside of the barrel top, the open upper end being covered with wire mosquito bar, with an introduction hole made in the wire screen and corked.

On April 20 about 30 pairs of mated *Eleodes letcheri vandykei* were placed in this cage, which had previously been seeded with wheat and planted to *Polygonum littorale*.

By June 25 the beetles were all dead in the cage, probably due to abnormal conditions as well as age, though no living beetles could be found in the fields at that time. Small larvæ 4 to 5 mm. (about three-sixteenths inch) in length were then to be found in the cage.

On examining the cage on November 14 the larvæ were found to be about 14 mm. (nine-sixteenths inch) in length and at about a depth of 12 to 24 inches below the surface. The soil in the rearing cage was as dry as powder to a depth of nearly 2 feet, but the desiccation did not seem to affect the larvæ.

[1] Psyche, vol. 2, no. 58, 1879, p. 209.

July 4, 1911, the cage was again examined and the larvæ were found to be about 1¼ inches long. From early in July to the middle of August it became necessary to be away from Govan, where this experiment was in progress. On returning, August 16, the root cage was examined and two adults found about 6 inches below the surface. They were hard and had evidently emerged some days before this date. When the boards which had been placed over the barrel to protect it during the winter were removed in the spring, a number of adults was found that had hibernated under this shelter. On the above date and at a depth of about 20 inches a very young false wireworm (3.5 mm. long) was found; it was pure white and had evidently but very recently hatched. This larva was undoubtedly the young of one of these accidentally introduced beetles.

The soil at this time was dry to a depth of 4 inches. On June 25 a pupa was found in the field, placed in a pill box with dirt, and on the 30th an adult *Eleodes letcheri vandykei* emerged. In the fields, where a farmer was plowing his summer-fallow—and it may be remarked that this is exceptionally late for working the summer-fallow in this country—pupæ were found turned out by the plow. A little flock of Brewer's blackbirds (*Euphagus cyanocephalus*) were walking in the furrow a few yards behind the plow and picking up the upturned insects.

From the middle of July until the grain is harvested adults are to be found in large numbers under the grain shocks and bundles as they stand in the field, and also under grain sacks. Most of the beetles are quite soft early in the season, but later become hard.

DESCRIPTIONS.

Eleodes letcheri vandykei Blaisd.

The egg (fig. 23).—The egg is bluntly oval in longitudinal section and circular in cross section; it measures 1.1 mm. in length and 0.62 mm. in diameter; it is of a pure glistening white color and absolutely without sculpturing. Ovarian eggs measured 1.17 mm. in length and 0.74 mm. in diameter.

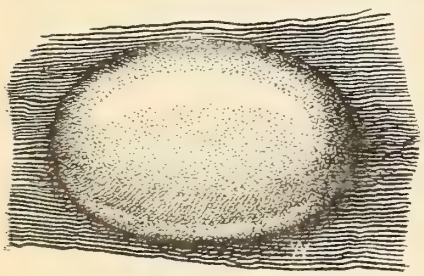

FIG. 23.—False wireworm, *Eleodes letcheri vandykei:* Egg. Greatly enlarged. (Original.)

The larva (fig. 24).—Elongate, subcylindrical, convex dorsally, flattened ventrally. Yellowish, ventral surface paler, anterior and posterior margins of first thoracic and posterior margins of succeeding segments brown; head slightly brown, edge of mandibles black, base of mandibles brown; claws, spines on legs, and caudal segment dark brown; antennæ pale yellow. Anterior and posterior margins of first and posterior margins of succeeding segments with striate marginal bands; band on anterior margin of first segment broader and more coarsely striate. Caudal segment scutelliform, flattened dorsally and convex ventrally, bearing 18 stout spines on its margin—4 on each lateral margin and 10 on terminal margin; a slight space equal to that occupied by one spine separates the lateral from the terminal spines. Several long hairs and a basal row

of short hairs on caudal segment. Head subquadrate, very convex, distance from base to labrum equal to one-half width of head, sides converging anteriorly, posterior angles rounded; two stout hairs on lateral dorsal surface; two oblong black eye-spots on lateral anterior part, a large one at base of antennæ, and a smaller one posterior and dorsad of this. Suture arising at base of each mandible flexed laterally and converging posteriorly to unite with the median suture at a distance from base of head equal to one-fourth distance from base to labrum; mouthparts usually directed ventrally. Labrum large, basal joint trapeziform, terminal joint rounded, bearing several hairs on margin, both joints margined anteriorly. Mandibles large, visible from above. Labium not covering mandibles, ligula broader than palpifer; labial palpi cylindrical, two-jointed, second joint papilliform; mentum larger than palpifer, submentum larger than mentum, all quadrangular and narrower at base than at anterior margin. Maxillæ larger than labium, stipes directed laterally, palpifer elongate and directed antero-medially; maxillary palpi at about middle of palpifer, three-jointed, first and second joints about equal in length, first stouter, third papilliform. Thoracic legs stout; first pair longer than width of thorax, second and third pairs one-third shorter; first pair very heavy, terminal hook as long as fourth joint, second joint bearing 2 stout short spines on inner distal margin, third joint bearing 3 marginal spines and fourth joint bearing 4 such spines.

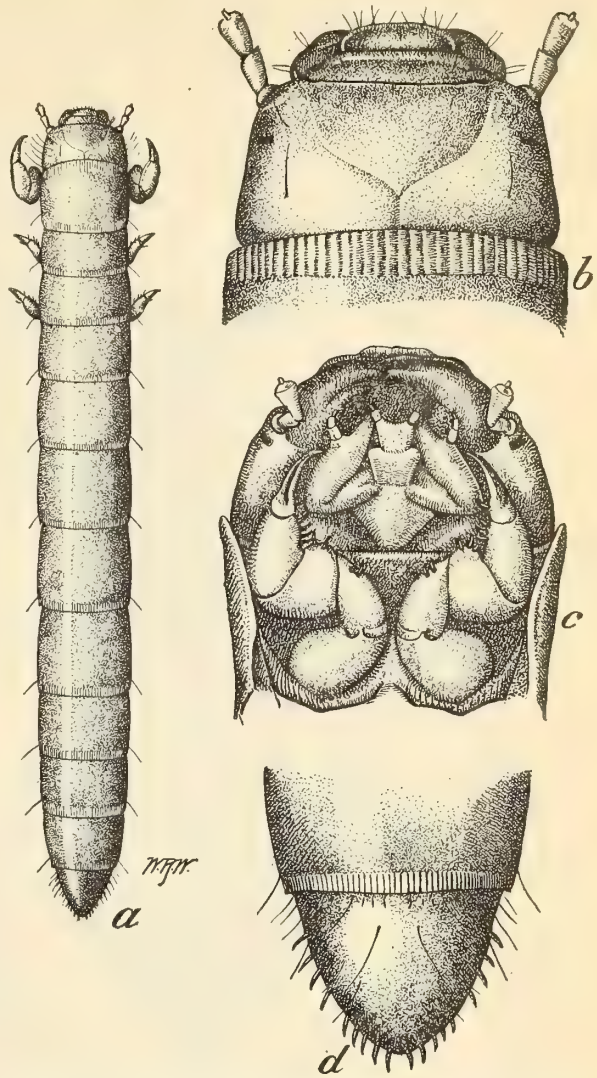

FIG. 24.—False wireworm, *Eleodes letcheri vandykei*. *a*, Larva, dorsal aspect; *b*, head, dorsal aspect; *c*, head, ventral aspect; *d*, caudal segment, dorsal aspect. *a*, Much enlarged; *b*, *c*, *d*, more enlarged. (Original.)

The pupa (fig. 25).—Length 11 mm., width 5.3 mm., arcuate dorsally, flattened to slightly concave ventrally. Entirely white when first pupated but eyes soon become black followed by tips of mandibles; just prior to emerging the elytra and dorsum of thorax become black. Head pressed to the prosternum. Pronotum very broad and protruding anterior to the head, making the latter invisible from above. Mesonotum very narrow and scutelliform, with indistinct transverse sulcus slightly anterior to middle. Metanotum sagittiform, about as broad at anterior margin as mesonotum. At the base of each elytron and of each secondary wing pad is a rounded swelling. Seven abdominal plates visible dorsally. Between dorsal and pleural abdominal

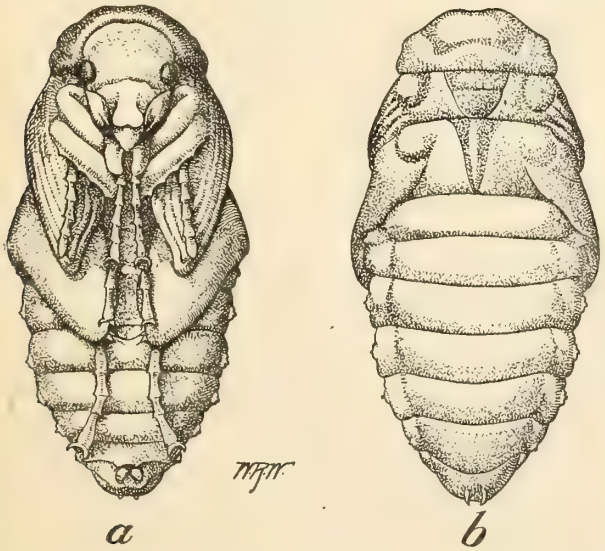

FIG. 25.—False wireworm, *Eleodes letcheri vandykei*: *a*, Pupa, ventral aspect; *b*, same, dorsal aspect. Much enlarged. (Original.)

plates is a distinct depression forming a submarginal groove. The caudal segment bears a pair of posteriorly directed spines near posterior margin dorsally and a pair of median anal lobes ventrally. Head, legs, and antennæ free. Antennæ passing behind first and second pairs of legs and over wing pads. Elytra folded ventrally over the posterior legs. Eyes conspicuous. Pleural margin of abdominal segments bearing mammiform tubercles. Body without hairs or bristles.

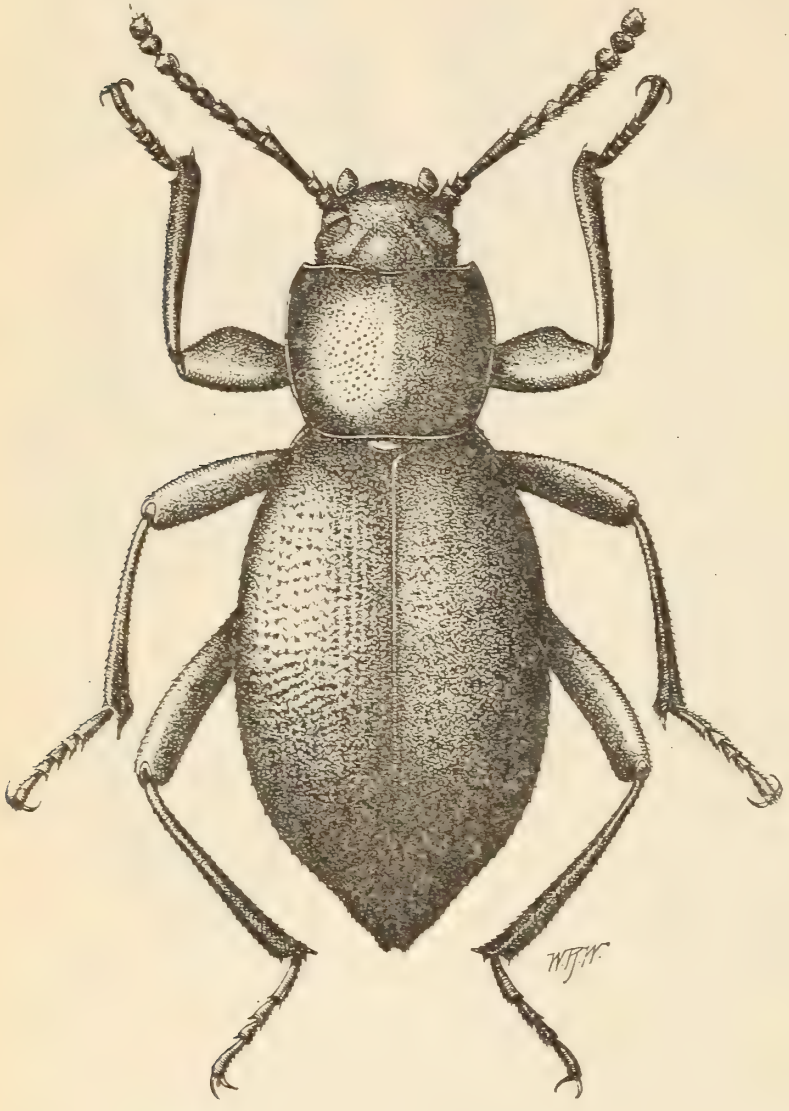

FIG. 26.—False wireworm, *Eleodes letcheri vandykei:* Adult, dorsal aspect. Much enlarged. (Original.)

The adult[1] (fig. 26).—More or less shining, elytra not pubescent. Antennæ with the third joint scarcely as long as the next two combined, fourth joint a little longer than the fifth, the latter slightly longer than the sixth, the latter and the seventh equal.

Pronotum usually widest at the middle, frequently widest just in front of the middle.

Elytra irregularly and quite densely muricately punctate, very minutely so on the dorsum, coarser on the sides and apex; from each puncture arises a rather short, stiff, curved, inconspicuous and semirecumbent seta. These are not evident on the inflexed sides.

Otherwise as in *letcheri*, but a little more robust.

Measurements.—Males: Length, 14.5–16 mm.; width, 5–6.5 mm. Females: Length, 15-16 mm.; width, 7.5 mm.

Genital characters as in *letcheri*.

Eleodes pimelioides Mann.

The egg.—Oval in longitudinal section and circular in cross-section; 1.34 mm. in length and 0.85 mm. in diameter; pure glistening white; without sculpturing of any kind.

The larva.—Elongate, cylindrical, convex dorsally, flattened ventrally. Yellowish, first thoracic and eighth abdominal segments brownish, ventral surface paler, anterior and posterior margins of first thoracic and posterior margins and anterior submarginal areas of succeeding segments brown, a distinct pale median vitta; head brownish posteriorly, edge of the mandibles black, base of the mandibles brownish; claws, spines on legs, and caudal segment brown; antennæ brownish. Anterior margin of first thoracic segment excavated, posterior margins on all segments except caudal

[1] The description of the adult given herewith is taken from "A Monographic Revision of the Coleoptera, belonging to the Tenebrionide Tribe Eleodiini, inhabiting the United States, Lower California, and Adjacent Islands," by Frank E. Blaisdell, Sr. Bul. 63, U. S. Nat. Mus., p. 136, 1909.

depressed, faintly striate. Caudal segment scutelliform, slightly convex dorsally, margined laterally, tip curved slightly upward, bearing 18 acute spines on margin—4 groups of 2 spines each on each lateral margin and 2 spines at tip. A number of hairs on dorsal surface and many on ventral surface. Head subquadrate, very convex, sides converging anteriorly, posterior angles rounded, 2 hairs on lateral dorsal and several hairs on ventral surface; 2 black eye spots on lateral anterior part of head, a large oblong one at the base of antennæ, and a smaller square one posterior and dorsal of this. Suture arising at the base of each mandible flexed laterally and converging posteriorly to unite with median suture near base of the head. Basal joint of labrum trapeziform, terminal joint rounded, trilobed, hairs on margin. Mandibles large, visible from above. Ligula broader than palpifer, labial palpi cylindrical, 2-jointed, second joint papilliform, mentum larger than palpifer, submentum larger than men-

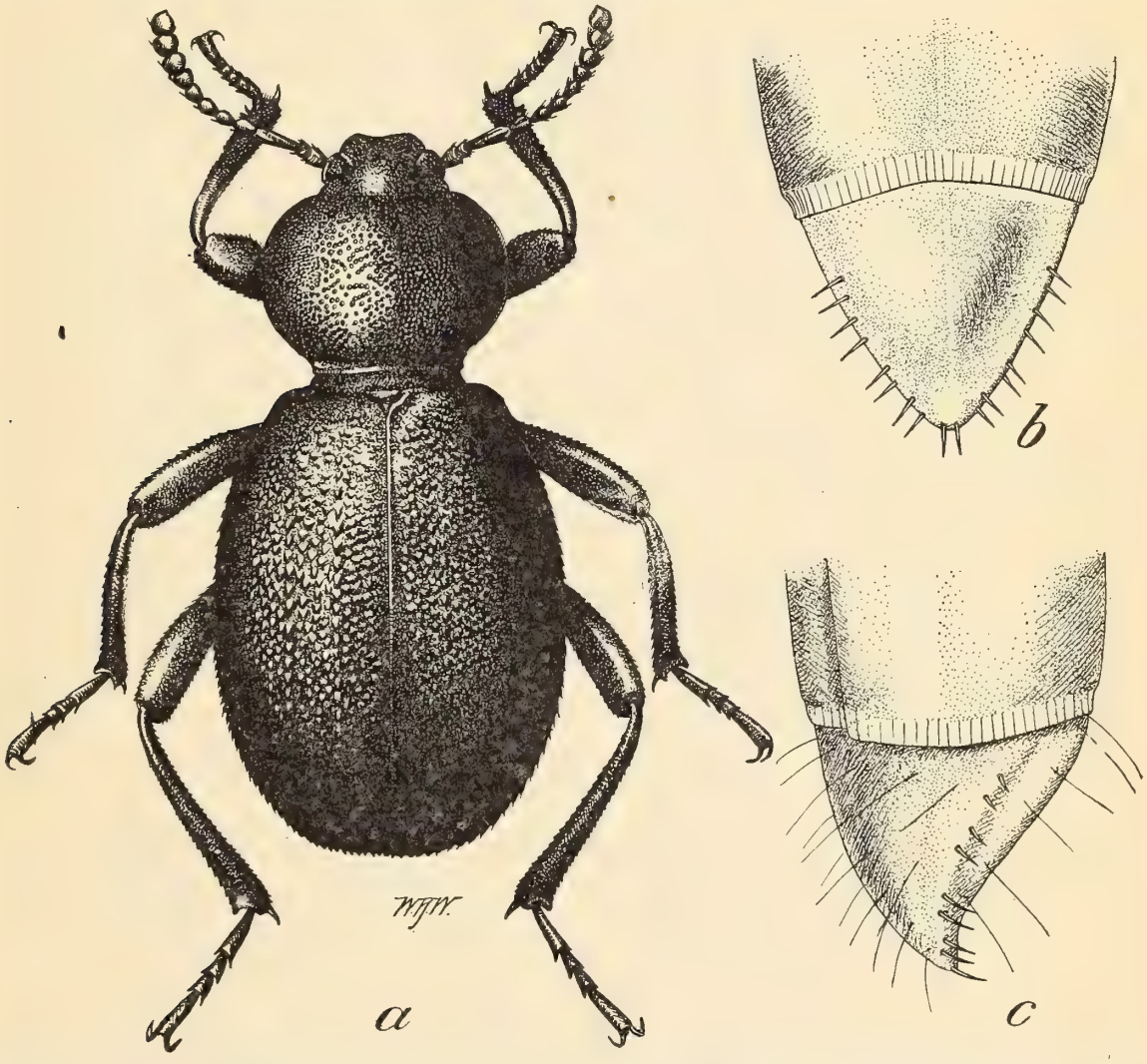

FIG. 27.—False wireworm, *Eleodes pimelioides: a*, Adult, dorsal aspect; *b*, caudal segment of larva, dorsal aspect; *c*, caudal segment of larva, lateral aspect. *a*, Much enlarged; *b*, *c*, more enlarged. (Original.)

tum. Legs 4-jointed. Second joint of anterior legs with 2 short stout spines on inner anterior margin; third joint of anterior legs with 3 longer spines on inner margin, and fourth joint with 3 still longer, stout spines; 2 spines on inner side and 1 spine on outer side of base of claw.

The pupa.—The pupa of this species is very similar to that of *Eleodes letcheri vandykei*, from which it can be distinguished, however, by a pair of rather stout spines at the apex of the secondary wing pads.

The adult (Fig. 27).[1]—The following description is from page 384 Dr. Blaisdell's monograph previously mentioned in this paper:

Moderately robust, ovate, feebly shining to opaque, about twice as long as wide; prothorax more or less strongly constricted at base, densely rugoso-punctate; elytra

[1] Originally described in Bul. Soc. Nat. Moscou, vol. 16, p. 274, 1843.

sculptured with small tubercles, which may be rounded or reclinate and more or less piliferous. Head densely punctate, antennæ somewhat slender, ninth joint triangulo-orbicular to transversely oval, tenth more or less transversely oval.

Pronotum subcordate to transversely suboval, widest near the middle, a fourth to scarcely a half wider than long; sides evenly and quite strongly arcuate to basal seventh, or subangulate at middle, rounded in front and quite rapidly converging posteriorly and sinuate at basal fourth, thence in each instance quite straight and parallel to the basal angles; base equal to the length or in some males shorter than the length; apical angles obtuse, frequently not in the least rounded, at other times more or less so.

Elytra quite broadly oval to subquadrate, widest at or behind the middle, a fourth to a third longer than wide; disc more or less deplanate on the dorsum, strongly, arcuately, and vertically declivous posteriorly; surface densely tuberculate, tubercles apparently arranged in rows on the dorsum or irregular throughout; each bears a very short, black seta near the apex; when arranged in rows there are very small muricate punctures scattered sparsely and irregularly between, always less distinct along the suture centrally; the tubercles are more or less rounded and shining, the interstices between more or less opaque. Otherwise as in *cordata*.

Male.—First two joints of the protarsi with tuft of yellowish pubescence near tip beneath; that of the second joint is rather small; tuft on the first joint of the mesotarsi quite small. Tufts somewhat long and truncate at tips. Otherwise as in *cordata*.

Female.—First joint of the anterior tarsi distinctly thickened at tip beneath. Otherwise as in *cordata*.

Measurements.—Males: Length, 12–14.5 mm.; width, 6–7 mm. Females: Length, 13–15.2 mm.; width, 6.5–8 mm.

Genital characters, male.—As in *cordata*.

Female.—Genital segment triangular, surface quite plain and slightly setose.

Valvula.—Dorsal plate oblong, feeble or scarcely narrowed apically, slightly explanate externally; apical margin nearly transverse to feebly oblique, inwardly not defined from the surface of the apex, angle obtuse and more or less feebly rounded.

Ventrolateral surfaces.—Submarginal groove distinct and well defined beneath the expanded external border of the dorsal plate. Otherwise as in *cordata*.

FOOD SUBSTANCES.

False wireworms are known to feed on the seed of wheat, oats, and corn, on the tubers of potato, on the fleshy roots of sugar beet, and on several garden crops, as well as on a variety of dead organic matter.

If several larvæ are placed in a small rearing cage with insufficient food they invariably prey upon one another until there is but a single survivor. Mr Swenk[1] observed that in cages where larvæ died of a disease their more fortunate survivors ate the dead individuals.

The adult beetles have been observed feeding on the seed of wheat and corn, on the leaves of corn, on *Polygonum littorale* and other weed leaves, and on decaying vegetable matter. An adult beetle was kept alive for several months in our laboratory. It was fed on wheat and occasionally drank from a piece of wet cotton.

[1] Journ. Econ. Ent., vol. 2, p. 336, 1909.

SEASONAL HISTORY.

The following life history was worked out for *Eleodes letcheri vandykei* at Govan, in the Big Bend region of Washington, and unless otherwise indicated the data refer to this species.

The adults emerge from hibernation in the early spring, about the middle of April, and after feeding for a short time on the leaves of various weeds, principally *Polygonum littorale*, mate and start oviposition. The eggs are deposited a few at a time in the ground, the adult female burrowing down through the soft dust to the moist soil below, usually to a depth of from 2 to 4 inches. The average number of eggs laid by one female is probably about 150. Five specimens of female *Eleodes letcheri vandykei* that were collected on April 30, 1911, were dissected and found to contain 199, 138, 161, 157, and 92 eggs, respectively. Most of these eggs were full-sized and probably mature, though one female contained 45 eggs and another 91 eggs which were about one-third full size. A female *Eleodes pimelioides*, collected May 1, 1911, at Pullman, Wash., was found to contain 167 eggs and 2 females of *Eleodes nigrina* collected late in April contained 96 and 58 eggs, respectively.

The eggs hatch in about 18 days, the recently emerged larvæ being cream-white, but rapidly assuming the normal amber-yellow color.

The larvæ feed throughout the ensuing summer, usually on decaying vegetable matter, hibernate, and resume feeding as soon as the soil becomes warm enough the following spring, but this time disastrously to the spring-sown grain. In June the larvæ transform to pupæ, and early in July the newly emerged adults commence to appear. They are quite soft on first emerging and take two or three days to become thoroughly hardened. These adults feed during the remainder of the summer, congregating in large numbers under the grain sacks, shocks, and any convenient shelter. They eat a small amount of grain and other vegetable matter and go into hibernation without mating. In the spring they resume activity and mate, thus completing the life cycle. They hibernate under boards, in squirrel holes, and in the ground. Prof. W. T. Shaw, of the Washington State College, in digging out burrows of a ground squirrel (*Citellus columbianus*), found specimens at a depth of 6 feet below the surface in the burrows. I have dug out the hibernating beetles at a depth of about 6 inches in the soil in wheat fields and also in barrel root-cages.

Larvæ of *Eleodes suturalis* were received by Mr. Theo. Pergande[1] on October 26, 1898, from McPherson, Kans. These pupated before May 19 and adults emerged May 30. From this note it would seem that *Eleodes suturalis* varies from *Eleodes letcheri vandykei* in its life

[1] Bureau of Entomology Notes, No. 8186.

history, hibernating as mature larvæ or pupæ and transforming to adults much earlier in the season than the latter.

The adults of the species herein treated seem normally to live but one season, but Dr. F. E. Blaisdell records keeping adults of *Eleodes dentipes* in confinement for over four years.

NATURAL ENEMIES AND PARASITES.

The hard chitinous integument, together with the offensive secretions, of these beetles render them almost immune to attack by birds. Several western vesper sparrows (*Poœcetes gramineus confinis*), two horned larks (*Otocoris alpestris* var.), a killdeer plover (*Oxyechus vociferus*), a "billy" owl (*Speotyto cunicularia hypogæa*), and a Brewer's blackbird (*Euphagus cyanocephalus*) were shot while feeding in the grain fields and the stomach contents examined; these failed to show any evidence that the birds had fed on adult Eleodes.

Of the domesticated birds, chickens and ducks eat adult Eleodes in large numbers. Twenty-five beetles were fed to one hen and were eaten very greedily. Young turkeys would not eat these insects. They would seize the beetle and immediately drop it and shake the head violently as though they disliked the taste, and after two or three similar experiences would learn to recognize these insects and would not touch them.

A large number of these beetles were fed to confined pheasants, and though the conditions were very abnormal, the results may be suggestive. Reeves pheasant (*Phasianus reevesi*) and the silver pheasant (*Gennæus nychthemerus*) ate the beetles freely, while the golden pheasant (*Chrysolophus pictus*) and the Lady Amherst pheasant (*Chrysolophus amherstæ*) refused even to notice the beetles. However, these birds seemed quite annoyed by our presence, and might have eaten the beetles had they not been frightened. No Chinese pheasants (*Phasianus torquatus*) were available, so we can not say whether or not these birds would be of any value as enemies of Eleodes.

From several sources we were informed that the sage hen (*Centrocercus urophasianus*) feeds largely on these beetles, the crop at times being gorged with the black chitinous fragments. In the records of the Bureau of Biological Survey of this department the following birds are listed as feeding more or less extensively on adult Eleodes:

California shrike (*Lanius ludovicianus gambeli*), road-runner (*Geococcyx californianus*), Lewis's woodpecker (*Asyndesmus lewisi*), western crow (*Corvus brachyrhynchos hesperis*), bronzed grackle (*Quiscalus quiscula æneus*), red-headed woodpecker (*Melanerpes erythrocephalus*), curve-billed thrasher (*Toxostoma curvirostre*), hairy woodpecker (*Dryobates villosus* var.), western mocking bird (*Mimus polyglottos leucopterus*), western robin (*Planesticus migratorius propinquus*), the field plover (*Bartramia longicauda*), the mallard (*Anas platyrhynchos*), and the baldpate (*Mareca americana*).

Dr. Blaisdell [1] refers to the ground owl (*Speotyto cunicularia hypogæa*) as one of their enemies, and further states that the butcher bird impales them on thorns.

It is very generally known among the farmers of the wheat regions of the Pacific Northwest that the Brewer's blackbirds (*Euphagus cyanocephalus*) follow the plow and eat the "white worms" (*Eleodes* pupæ) when the summer-fallow is being worked. The birds are to be seen walking in the furrows and flying away with their beaks filled with the soft white pupæ.

The western bluebirds (*Sialia mexicana occidentalis*) were seen at Govan, Wash., in large flocks feeding on the larvæ which had been driven to the surface by an unusually heavy rain.

The stomachs of several horned toads (*Phrynosoma douglasii douglasii*) were examined and found to contain fragments of Eleodes larvæ, but several of these toads kept in captivity refused to eat the adult beetles, though they would feed voraciously on other beetles. These little horned toads, or, as they are locally known, sand toads, are without doubt one of the most valuable animals in the western dry-farming regions. In the Southwest a larger species (*Phrynosoma cornutum*), with long stout spines on the head, supplants the former species. These toads move very rapidly and eat enormous numbers of insects. The garden toad (*Bufo* sp.) is recorded in the files of the Bureau of Biological Survey as feeding on Eleodes. Dr. Blaisdell [2] gives the skunk as a natural enemy of these beetles.

In the files of the Bureau of Entomology there is a note (No. 8186) by Mr. Theo. Pergande, wherein he records having received two larvæ from McPherson, Kans. These pupated, and later one of these pupæ was killed by an ant (*Tetramorium cæspitum*).

Another of Mr. Pergande's notes [3] records receiving an adult of *Eleodes suturalis* from Mr. C. E. Ward, of Belvidere, Nebr. This beetle was placed in a cigar box, and on examining the box on the following morning a large number of larvæ were noticed crawling about. These larvæ later spun cocoons around the edge of the box and were believed to be microgasterid parasites that had issued from the beetle. The adult parasites were later determined as *Perilitus* n. sp., and these are preserved in the National Museum collections.

The author found an adult beetle with the abdomen nearly filled by a nematode worm, but lost the specimen, making further determination impossible. Mr. Myron Swenk [4] records a disease, probably caused by bacteria or a fungus, that attacks the larvæ. The

[1] Bul. 63, U. S. Nat. Mus., p. 29, 1909.
[2] Loc. cit., p. 29.
[3] Proc. Ent. Soc. Wash., vol. 2, pp. 211, 219, 1892.
[4] Jour. Econ. Ent., vol. 2, p. 335, 1909.

first symptom of this disease is a small red spot on one of the body segments, usually on the first thoracic or the terminal abdominal segment. This spot enlarges, finally encircling the body, and within a very short time the insect succumbs. This disease was so prevalent as to interfere with much of Mr. Swenk's experimental work.

REMEDIAL AND PREVENTIVE MEASURES.

If a field is well stocked with false wireworms at the time wheat is sown, remedial measures are of little avail, as was demonstrated by our experiments carried out in the Big Bend country of Washington. The insects are well adapted to the present agricultural practices of the spring-wheat growers in the Pacific Northwest. Here the plowing of summer-fallow land is commenced as early as possible in the spring, which in the average season is in April. Those who can spare teams and men often commence while the seeding of the crop in other fields is in progress. The most progressive farmers then disk their fallow land in June so that this will be well finished when haying commences.

By slightly modifying this procedure an enormous number of these beetles would be destroyed. Instead of plowing early in the spring and disking in summer, reverse the process. Disk as early as the land can be worked and the apparatus is available, which will usually be in April. This will conserve the moisture fully as well as plowing. Then plow as late as possible; if the land has been well disked and the men and horses can be spared, it is well to defer this plowing to late July and early August. At this time the beetles are in the pupal, or, as they are commonly called, "white-worm," stage. They can not move through the ground as can the active larvæ, but can merely squirm when irritated. The plowing, which should be deep to be effective, turns out great numbers of these pupæ, and they are either eaten by birds or killed by the burning sun. Many more are destroyed by being crushed or suffocated in the broken pupal cells. Aside from killing many Eleodes pupæ, this practice of late plowing the summer-fallow would greatly aid in weed eradication. The early disking would not bury the weed seed to retard germination; all the seed would develop; then the late plowing would destroy the entire crop of weeds. If the weeds start very early, a second disking may be necessary, as weeds very rapidly deprive the soil of its moisture.

Concerted effort and very thorough work are absolutely essential to render this treatment appreciably effectual. The cooperation of all the farmers over a considerable area is advised, as the adult beetles walk rapidly and will readily reinfest a well-treated ranch, coming in from an adjoining, poorly worked field or pasture.

This treatment is by no means advocated for those farmers who find it impossible to disk their summer-fallow, as leaving the land untouched until July would cause all the accumulated winter's moisture to evaporate, and the plowing would simply be stirring the dust and be of no value whatever.

In the spring of 1910 a series of experiments was carried out at Wilbur, Wash., to determine the value of certain substances alleged to be useful as poisons or repellents against elaterid larvæ. Eleodes larvæ were also quite numerous in the fields where these experiments were carried out; hence mention of the results, though relating principally to another insect, may not be out of place here.

Seed in bulk was treated with the following substances: Lead arsenate, at the rate of two-thirds of a pound per bushel of seed, dissolved in water; strychnine sulphate, at the rate of two-thirds of an ounce per bushel of seed, dissolved in water; coal tar applied until seed was all coated, then sanded until dry. The substances were stirred into the grain thoroughly with a wooden paddle and then allowed to dry several days.

The experiments were sown in strips with a wheat seeder 11 feet wide and one-half of a mile long. Untreated check strips were planted between each treated plat.

Just after sprouting the percentage of damage done by insects was estimated by counting the damaged and undamaged seed in several areas of 1 square yard each in each plat. The results were entirely negative as all the plats, including the checks, were about equally attacked.

These treatments, even had they been found efficient, would have been impracticable from an economic standpoint. The poisons were too expensive and the application too expensive and laborious, and, in addition, the coal-tar treatment, even after drying several days, so clogged the seed cups on the seeder as to cause very uneven distribution of seed.

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U. S. D. A., B. E. Bul. 95, Part VI. C. F. I. I., May 31, 1912.

PAPERS ON CEREAL AND FORAGE INSECTS.

THE LEGUME POD MOTH.

(*Etiella zinckenella schisticolor* Zell.)

By James A. Hyslop,
Agent and Expert, Cereal and Forage Insect Investigations.

HISTORICAL.

The first mention of the legume pod moth (*Etiella zinckenella schisticolor* Zell.) as of economic importance in the United States is found in the unpublished notes of Mr. Theodore Pergande [1] in the files of the Bureau of Entomology, and refers to a number of lima-bean pods sent in by Mr. Albert Koebele from Eldorado County, Cal., on July 21, 1885. The larvæ were reported as doing considerable damage to the bean crop in that region. They left the pods and, if not full grown, entered other pods to continue feeding or, if full grown, constructed slight cocoons in the bottom of the rearing jar and pupated. Adults emerged September 2 and September 15.

A similar reference,[2] from the same source, refers to a number of pods of *Crotolaria incana* collected by Mr. E. A. Schwarz at Cocoanut Grove, Fla., on May 9, 1887, and sent to the Bureau of Entomology. The larvæ were eating the seed, and from these on May 16 an adult emerged. From a second lot of seed pods from the same source received on June 1, three more moths emerged on the 24th.

On May 2, 1896, a number of pods of *Astragalus* sp. were received by the bureau from Mr. C. L. Marlatt,[3] the material having been collected at Neucestown, Tex., infested with larvæ of *Etiella zinckenella*. On May 13 a braconid parasite issued, and on June 5 an adult moth emerged.

A single specimen was received from Mr. E. E. Bogue,[4] of Stillwater, Okla., on August 17, 1896, which he had previously reared from the seed pod of *Crotolaria sagittalis*.

Dr. F. H. Chittenden,[5] of this bureau, has published a paper on this insect in which the records made by Mr. H. O. Marsh are incor-

[1] Bureau of Entomology Notes, No. 3819.
[2] Bureau of Entomology Notes, No. 4129.
[3] Bureau of Entomology Notes, No. 7044.
[4] Bureau of Entomology Notes, No. 7173.
[5] Bul. 82, Pt. III, Bur. Ent., U. S. Dept. Agr., p. 25, 1909.

porated. Mr. Marsh found the larvæ attacking lima beans at Santa Ana, Garden Grove, Anaheim, and Watts, in California. At Garden Grove they had destroyed 40 per cent of the crop.

SYNONYMY AND DISTRIBUTION.

The species *Etiella zinckenella* was described by Treitschke [1] in 1832, and the variety *E. zinckenella schisticolor* was described as *E. schisticolor* in 1881 by P. C. Zeller [2] from two specimens, a male and a female, collected from "very different parts of North America." The male was from California and was collected October 8, but of the female he has nothing to say. He also refers to specimens of *E. zinckenella* examined by him from Sierra Leone, West Africa; Madagascar; Honda, Colombia, South America; and "Carolina" in this country. Later Rev. G. D. Hulst [3] redescribed this species under the name *Etiella villosa*, and gave Colorado and Califorina as the habitat. Dr. H. G. Dyar in his catalogue gives Arizona as an addition to the habitat.

The typical *E. zinckenella* is represented in the National Museum collection by specimens from Hampton, N. H.; Weekapong, R. I.; Key West and Archer, Fla.; Oxbow, Saskatchewan; Texas; Stillwater, Okla.; and Denver, Colo. The variety *E. zinckenella schisticolor* is represented by specimens from Stockton, Utah; Springfield, Idaho; Eldorado, Clairmont, Alameda, and San Diego, Cal.; Nogales, Ariz.; and Pullman, Wash. It will be noted that all the specimens of the variety were collected west of or in the Rocky Mountains.

Etiella zinckenella schisticolor differs very slightly from the typical form. It has a suffusion of gray scales on the primaries as its chief distinctive character. A number of specimens from Florida, one specimen from Rhode Island, and one from New Hampshire very closely resemble the European specimens of *E. zinckenella*.

A possible explanation of the above facts may be that the variety *schisticolor* is a native of the Pacific slope of this continent, while the forms found in the eastern United States are the typical *E. zinckenella* recently introduced into this country from the Old World or South America.

FOOD PLANTS.

Larvæ of *Etiella zinckenella* have been recorded as feeding on the seed of several species of leguminous plants. In California (Eldorado County) Mr. A. Koebele [4] found them doing considerable damage to lima beans and they were recently found by Mr. H. O. Marsh,[5] of this bureau, working on the same crop in that State. Mr. E. E.

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[1] Die Schmetterlinge von Europa, von Friedrich Treitschke, 9 Band, p. 201, 1832.

[2] Horæ Societatis Entomologicæ Rossicæ, vol. 16, p. 177, 1881.

[3] Ent. Amer., vol. 3, p. 133, 1887.

[4] Bureau of Entomology Notes, No. 48 K.

[5] Bul. 82, Pt. III, Bur. Ent., U. S. Dept. Agr., p. 25, 1909.

Bogue [1] found the larvæ in the seed pods of the common rattlebox (*Crotolaria sagittalis*) at Stillwater, Okla., and Mr. E. A. Schwarz [2] found them in the pods of a tropical species of this genus (*Crotolaria incana*) at Cocoanut Grove, Fla. Mr. C. L. Marlatt [3] records finding the larvæ in the seed pods of milk vetch (*Astragalus* sp.). They are also recorded by Herrich-Schäffer [4] as feeding in the seed pods of *Spartium junceum* near Vienna, Austria.

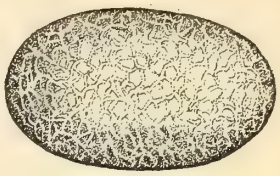


FIG. 28.—The legume pod moth (*Etiella zinckenella schisticolor*): Egg. Greatly enlarged. (Original.)

During 1910 and 1911 the author reared the species from the pods of common lupines (*Lupinus* spp.) and Canada field peas at Pullman, Wash.

DESCRIPTION.

THE EGG.

(Fig. 28.)

Egg glistening white, bluntly elliptical in outline and circular in cross section, measuring 0.58 mm. in length and 0.31 mm. in diameter. Chorion very delicate, colorless, and with fine irregular corrugations on the surface.

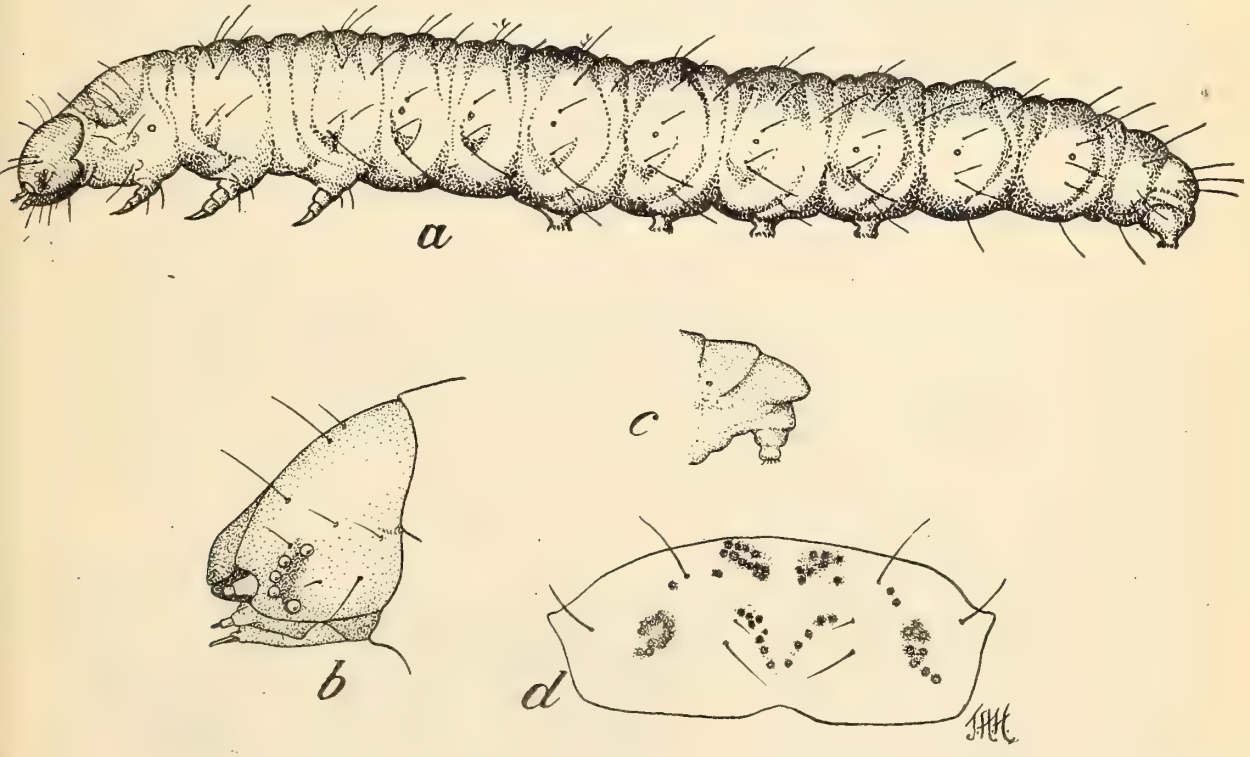


FIG. 29.—The legume pod moth. Larva: *a*, Side view; *b*, lateral aspect of head; *c*, caudal segments; *d*, pronotal shield. *a*, Enlarged; *b*, *c*, *d*, greatly enlarged. (Original.)

THE LARVA.

(Fig. 29.)

Full-grown larva from 12 to 17 mm. in length and from 2.5 to 3.5 mm. in diameter. Head yellow, black patch over ocellar area; mandibles and tip of labrum black; five ocelli arranged in an anteriorly directed semicircle at base of antennæ. Dor-

[1] Bureau of Entomology Notes, No. 7173.
[2] Bureau of Entomology Notes, No. 4129.
[3] Bureau of Entomology Notes, No. 7044.
[4] Syst. Bearb. der Schmett. von Europa, vol. 4, p. 72, 1849.

sum ruddy pink, except the pronotum (immature larvæ are evenly pale green or cream colored, with head and pronotal shield black or brown), the pleural and ventral surfaces pale green or cream white. Head pale yellow. Tips of thoracic legs and head brownish yellow. Five pairs of prolegs situated on segments 3, 4, 5, 6, and 9; the last pair can be retracted, so as to be almost invisible. Pronotum yellowish, with brown or black markings as follows: Two medial pairs of dot patches, the posterior pair nearly touching the posterior margin and somewhat oblong in outline, the anterior pair approaching the anterior margin and linear in outline, being for the most part made up of a single row of dots; both pairs converging anteriorly, the anterior rows forming a V. Posterior margin bearing four bristles. Two pairs of bristles flanking the anterior median patches of dots, the posterior bristle in each pair short.

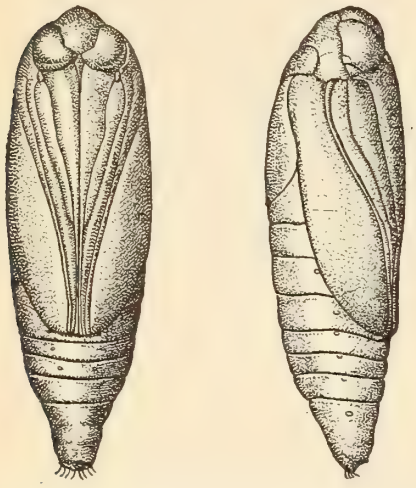


FIG. 30.—The legume pod moth: Pupa. Greatly enlarged. (Original.)

THE PUPA.

(Fig. 30.)

Pupa from 6 to 10 mm. in length, amber-yellow, with the tip of the abdomen, the edges of the abdominal segments, and margins of the wings outlined in brown. Fourth, fifth, and sixth abdominal segments each bearing a pair of short spines on the ventral surface. Abdominal segments 2 to 9 bearing well-defined brown spiracles. Terminal abdominal segment provided with a transverse row of 6 hooked bristles and a pair of lip-shaped tubercles on its dorsal surface.

THE ADULT.

(Fig. 31.)

"The adult expands 24–27 mm. Labial palpi russet-gray above, gray below. Maxillary palpi yellowish, brown on end. Head, collar and fore-thorax orange fuscous. Thorax behind fuscous gray. Abdomen fuscous; fore wings mouse color, consisting of bluish gray, overlaid partly with fuscous. A broad white stripe extending from base along costa to apex. Extreme edge of costa of ground color broadening outwardly just beyond middle and fading away toward apex. A dull yellowish basal stripe reaching from white costal stripe to inner margin, edged inwardly with a row of maroon-brown scales, the scales being longer than usual. Hind wings fuscous, deepening outwardly, with dark marginal line. Beneath even glistening, very light fuscous." (Hulst, Trans. Amer. Ent. Soc., vol. 17, p. 170, 1890.)

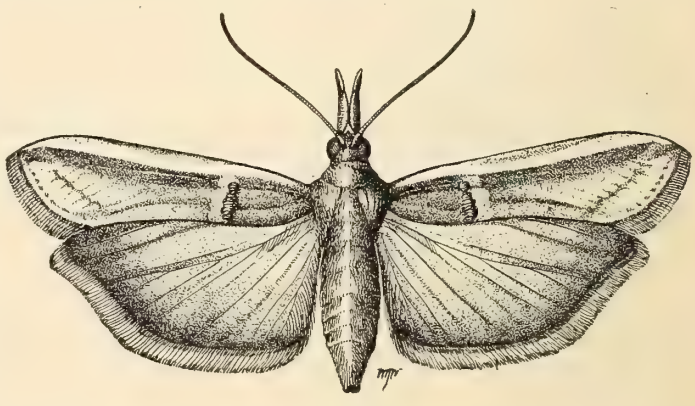


FIG. 31.—The legume pod moth: Adult. Enlarged about 2½ diameters. (Original.)

SEASONAL HISTORY.

On July 26, 1911, an eggshell was found on the outer surface of the calyx of a well-filled though still green lupine seed pod. The larva, which had evidently emerged only a few minutes before it was dis-

covered, measured 1.2 mm. in length and was found just inside the pod at the terminus of a burrow which led from just in front of the egg through the calyx and pod wall. The hole through which the larva emerged from the eggshell was terminal, round, and very neatly cut. A few days later two eggs were found on the calcyces of field peas; these were brought into the insectary but failed to hatch.

During late July and early August, 1911, larvæ in all stages of development, from very small specimens, evidently just hatched, to those which were mature and spinning cocoons, were found in both the pods of field peas and lupines. The larvæ on first emerging are pale green or cream colored, the pronotal plate and head being entirely black or brown; with the first molt the pronotal plate assumes the characteristic pattern described elsewhere in this paper, but the body does not assume the rosy tint as described until nearly mature.

The larvæ feed for about three weeks, only partly consuming the peas, as is seen in figure 32, destroying them as seed, besides greatly reducing their weight as stock feed. The pod always contains a mass of frass held together by a loosely constructed web. The larva will leave one pod and enter another if the food supply is exhausted, or if for any other reason the pod becomes uninhabitable. When mature, if the peas are still unharvested in the field, it emerges from the pods and enters the ground to pupate, or if the pods have been harvested it spins a tough silken cocoon in the nearest available sheltered place.

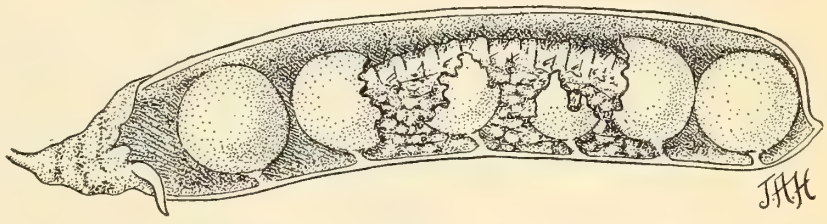


FIG. 32.—The legume pod moth: Larva feeding in a pod of field pea. Enlarged. (Original.)

Larvæ that become mature during the warm weather of early August, out of doors, or later under laboratory conditions, pupate immediately and emerge as adults in about six weeks. Adults have been obtained in our laboratory on August 5 and as late as August 28. Whether these lay eggs which pass the winter successfully, or whether they hibernate as adults, is still undetermined. Larvæ that reach maturity in late September, when the nights are cold, spin their cocoons and hibernate therein as larvæ, pupating in the spring and emerging at the time the earliest lupines are setting seed.

On the lupines there are very probably two generations a year. The moths of the first generation, coming from hibernating larvæ, lay all their eggs on the lupines, as the field peas are just commencing to grow. The offspring of this generation mature late in July and, finding the field peas ripening, very naturally turn their attention to these large areas of suitable food as well as to their natural food, the later lupines.

Mr. C. L. Marlatt [1] reared adults on June 5, 1896, from larvæ that were collected May 2 of that year at Nuecestown, Tex. Mr. Albert Koebele [2] reared adults on September 2 and 15, 1885, from larvæ collected June 21 at Rattlesnake Bridge, Eldorado County, Cal. Mr. Koebele also noticed the entrance holes of young larvæ and the exit holes of older larvæ in the pod husks. He says, "The larvæ * * * spun a web on the bottom of the jar in which they pupated."

Mr. Theodore Pergande [3] received a number of larvæ from Mr. E. A. Schwarz collected at Cocoanut Grove, Fla., on May 9, 1887, and on May 26 reared an adult from this material. More material from the same source was received on June 1, and on the 24th three more adults emerged.

Mr. H. O. Marsh obtained adults from January 9 to February 25, 1909, from larvæ collected October 22, 1908, at Anaheim, Cal.[4]

These observations indicate that two generations a year is characteristic of this species, the adults of the first appearing in early June and those of the second in September. The adults obtained in January and February were reared under laboratory conditions, which very probably accelerated their development. In the more southern parts of its range this species may have more than two generations.

FIELD WORK.

July 21, 1909, while examining the seed pods of the common lupine (*Lupinus* sp.) many were found to contain lepidopterous larvæ. In such pods the seeds were always more or less destroyed. The pods also contained a mass of frass which was held together by a loosely constructed web. A few days later, on examining the collected material, several of the pods were found with newly eaten holes in the sides and two larvæ were found with half their bodies within fresh pods.

On August 7 one of the larvæ, very plump, was found still in the pod, it having in the meantime become suffused with a rosy color. This larva had constructed a loose silken cocoon, through which its body could be easily seen. Ten days later the larva pupated and emerged as an adult (*Etiella zinckenella schisticolor*) September 28.

In the rearing cages with solid bases most of the larvæ left the seed pods and spun their cocoons among the litter and dirt in the bottom of the cages. In cages with bottoms of earth the larvæ always burrowed 2 or 3 inches below the surface to pupate.

On August 1, 1910, Mr. M. W. Evans, of the Bureau of Plant Industry, told the author of a larva that he was finding in the field-pea

[1] Bureau of Entomology Notes, No. 7044.
[2] Bureau of Entomology Notes, No. 48 K.
[3] Bureau of Entomology Notes, No. 4129.
[4] Bul. 82, Pt. III, Bur. Ent., U. S. Dept. Agr., p. 25, 1909.

pods in his experimental plats at Pullman, Wash. On examining some of these larvæ it was found that they resembled those of *Etiella zinckenella schisticolor* that had been found in lupine-seed pods the previous year, differing only in being larger, measuring about 17 mm. in length, while those from lupine measured only 13 mm., due, without doubt, to the difference in food plant.

The following day a number of the larvæ were collected from the field-pea pods and placed on earth in a flowerpot, into which they immediately burrowed.

From a larva placed in a pill box an adult emerged on August 27 and on the same day two moths emerged from the earth in the flowerpot.

EXPERIMENTAL WORK CARRIED ON DURING THE SEASON OF 1910.

In the spring of 1910 the Bureau of Plant Industry planted over 100 varieties of field peas at Pullman, Wash. These were planted

FIG. 33.—The work of the legume pod moth (upper row) compared with that of the pea weevils (Bruchidæ) (lower row). Enlarged. (Original.)

in plats 1 rod square, in order to study development and adaptability of the various varieties under semiarid conditions. Mr. M. W. Evans has very kindly permitted the use of his field notes, and of the crop when harvested from these plats, which has greatly facilitated this investigation. These notes indicated the time of planting, the time the first flowers of each variety came into bloom, the time of maximum blooming, and the time of last blossoms. The seed harvested from each plat was kept in individual packages.

By actual count the writer determined the percentage of damage to each variety of field peas by these moths. The "worms" do not usually consume the entire seed, but so far destroy it as to render germination impossible. Seed thus damaged is easily distinguished from that attacked by Bruchus. The latter makes a very smooth round exit hole, while the former gnaws into the seed very irregularly. (See fig. 33.)

Figure 34 is a plan of the experimental plats and shows very clearly that the attacks of the pod moth were not restricted to any one part of the field, but were more or less promiscuously distributed. The plantings were made on a gentle slope, the upper side being to the south, thus giving a northerly exposure. The vacant rectangle in the center of the plan indicates a wheat-straw stack. All sides of the field were bounded by grain fields, and the roadside was practically

				1	2	3	4	5	6	7	8	9	10
			11	12	13	14	15	16	17	18	19	20	21
22	23	24	25	26	27	28	29	30	31	32	33	34	35
36	37	38	39	40	41	42	43	44	45	46	47	48	49
50	51	52	53	54	55	56	57	58	59	60	61	62	63
64	65	66	67						68	69	70	71	72
73	74	75	76		STRAW STACK				77	78	79	80	81
82	83	84	85						86	87	88	89	90
91	92	93	94	95	96	97	98	99	100	101	102	103	104
105	106	107	108	109	110	111	112	113	114	115	116	117	118
119	120	121	122	123	124	125	126	127	128	129	130	131	132
133	134	135	136	137	138	139	140	141	142	143	144	145	146
147	148	149	150	151	152	153	154	155	156	157	158	159	160

FIG. 34.—Planting plan of plats used in investigations of the legume pod moth during the season of 1910. (Original.)

without weeds of any kind. The plats were separated from each other by strips of oats 1 yard in width.

Field peas vary greatly in texture of the seed, time of blooming, time of maturing seed, and adaptability to semiarid conditions. The variability, however, is confined to the varieties to a large extent, the individuals of a variety being quite uniform in response to given conditions. This fact at once opened the question of a worm-resistant variety. The results arrived at by this investigation are very suggestive. The actual records made in the investigation are to be found in Table I, but to make the results more readily available the

variations in percentage of damage under several variables are graphically illustrated by diagrams.

TABLE I.—*Record of experimental work on the legume pod moth for the season of 1910.*

Plat No.	B. P. I. No.	Began blooming.	Full bloom.	Blooming ended.	Total number of seed.	Number of seed damaged.	Per cent damaged.
51	21289	June 14	June 17	July 6	21,802	0	0.0
97	24177	June 16	June 21	...do	14,098	11	.0
102	21288	June 17	June 23	July 9	19,920	0	.0
26	11097	...do	June 21	July 12	7,506	0	.0
20	11112	...do	June 23	...do	24,722	15	.0
43	22639	June 19	June 24	...do	9,010	0	.0
46	24895	...do	June 25	...do	13,828	10	.0
31	24179	...do	June 26	...do	19,508	8	.0
59	22077	June 14	June 21	July 14	14,517	0	.0
2	23331	June 21	June 26	July 16	6,662	2	.0
100	22007	June 16	.....	July 17	15,484	4	.0
$\frac{1}{10}$ acre	20466	June 28	July 1	...do	22,117	4	.0
8	22036	June 23	...do	July 24	15,539	14	.0
16	21709	June 26	...do	...do	24,581	11	.0
101	21605	June 10	June 16	July 3	26,431	36	.1
4	23290A	June 26	July 1	July 7	11,781	21	.1
63	22638	June 10	June 17	July 12	30,276	36	.1
149	23525	June 19	June 26	...do	10,500	20	.1
5	22640	June 26	July 1	July 26	13,625	25	.1
150	23290H	July 1	July 6	.....	19,413	33	.1
72	17006	.....	...do	Aug. 3	23,707	37	.1
19	18455	June 24	July 1	July 14	11,310	30	.2
32	24178	June 21	.....	July 22	12,694	31	.2
73	24940	...do	June 26	...do	13,063	28	.2
70	20467	June 26	June 30	...do	18,495	45	.2
42	24262	June 16	June 23	July 17	9,792	33	.3
48	19389	June 23	June 28	July 24	22,960	80	.3
13	22040	July 1	July 9	Aug. 3	19,039	65	.3
41	17486	June 26	July 3	July 24	13,252	66	.4
7	22045	...do	July 6	July 26	14,522	72	.4
55	12888A	June 30	...do	.....	10,477	43	.4
10	19786	...do	July 3	July 26	11,939	59	.4
103	20382A	...do	July 6	July 29	20,335	85	.4
44	19290	June 19	June 24	July 6	3,346	21	.6
17	21290	June 21	June 30	July 17	22,372	136	.6
54	16439	June 23	.....	...do	24,937	169	.6
148	23547	June 26	June 30	.....	14,585	95	.6
49	17483	June 30	July 6	July 26	33,529	229	.6
104	19788A	...do	...do	.....	16,509	107	.6
61	16437	June 26	...do	July 29	9,350	63	.6
35	22043	...do	...do	July 26	20,588	145	.7
14	22038	July 3	...do	...do	20,255	145	.7
98	23850	June 19	June 26	July 17	13,971	138	.9
76	18456	June 23	...do	.....	13,639	131	.9
25	16130	...do	July 1	Aug. 3	2,279	21	.9
80	10274A	July 9	July 17	Aug. 14	10,290	122	1.1
56	12887	June 26	June 30	July 22	9,848	119	1.2
87	23851	...do	...do	July 24	21,895	292	1.3
60	17483A	June 28	July 6	Aug. 3	9,400	127	1.3
90	20381	July 17	July 24	Aug. 13	8,887	118	1.3
69	23847	June 28	July 6	Aug. 3	19,007	302	1.5
58	22078	June 23	.....	July 24	8,444	164	1.9
160	16436	June 24	June 30	July 22	18,724	382	2
37	22044	July 1	July 9	Aug. 3	18,555	411	2.2
12	22041	July 3	July 12	July 26	12,053	278	2.3
77	19787	July 2	July 9	.....	14,699	389	2.6
82	19709	July 3	July 14	Aug. 9	14,713	387	2.6
15	22037	...do	July 9	July 26	22,148	683	3
40	19785	June 26	July 6	...do	10,447	346	3.3
159	16437A	June 28	...do	...do	7,105	244	3.4
36	22046	July 1	...do	...do	11,191	391	3.4
38	22042	July 3	July 9	...do	13,822	502	3.6
88	22049	...do	...do	July 29	23,573	893	3.7
99	23848	June 26	July 3	Aug. 3	15,066	563	3.7
$\frac{1}{10}$ acre	16819	July 3	July 9	...do	6,581	281	4.2
156	17483E	July 9	July 14	July 29	10,732	821	7.6

The diagram, figure 35, shows the maximum (solid line) and minimum (dotted line) percentage of seed damaged in all varieties which commenced blooming at any given time. It shows that varieties

which began blooming during and after the last week in June were decidedly the most severely attacked.

Figure 36 shows similar data on all varieties in full bloom at any given time, besides very clearly showing that such varieties as were in full bloom between the first and last weeks of July were the most severely attacked.

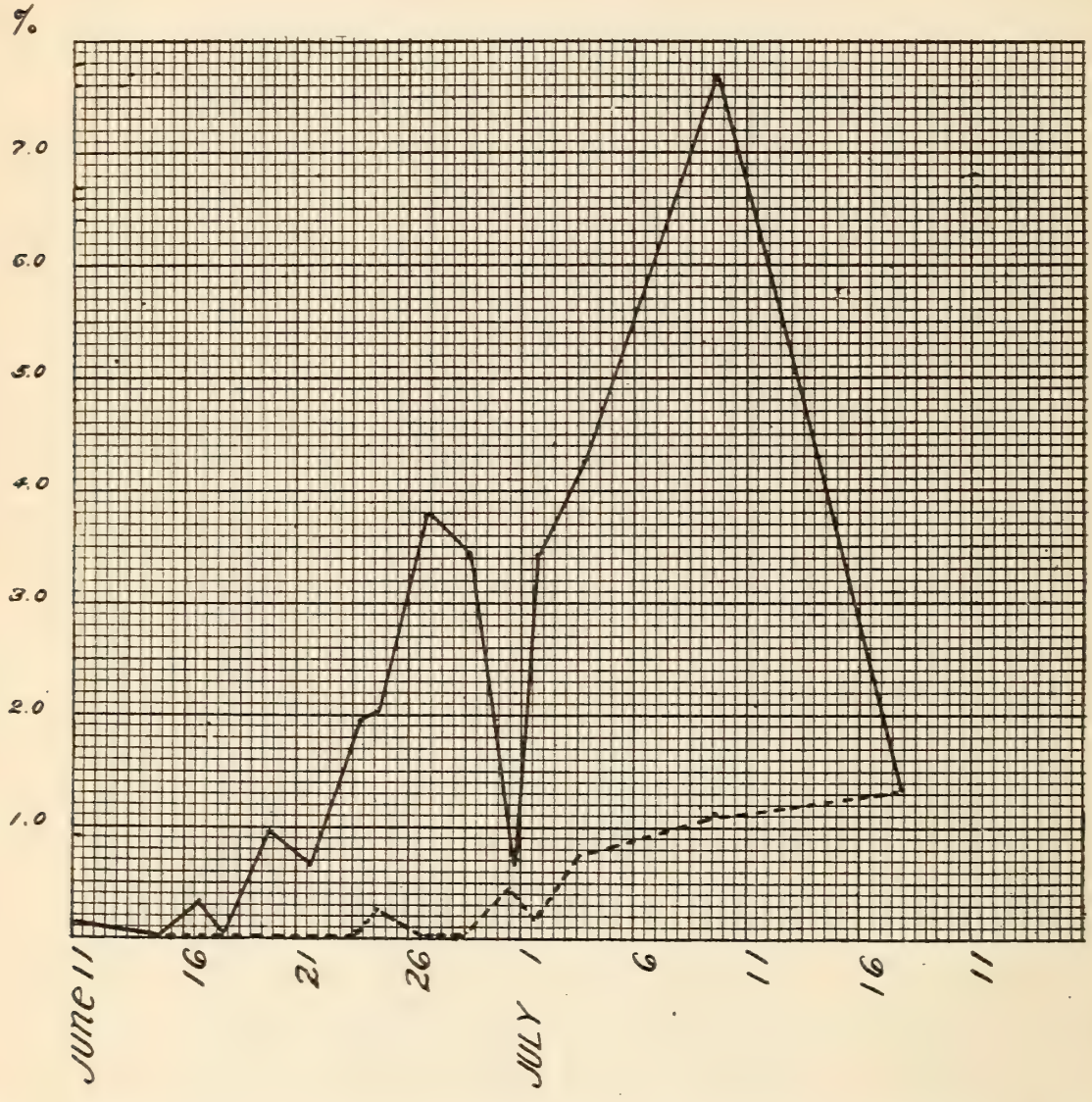


FIG. 35.—Diagram showing maximum and minimum damage done by the legume pod moth to varieties of peas commencing to bloom on a given date in 1910. (Original.)

Figure 37 shows similar data on all varieties which ceased blooming on any given date, and indicates that such varieties as had ceased blooming before the middle of July were only slightly damaged.

As the time the plants are in full bloom is very evidently of the greatest significance, Table II and figure 38 were arranged to show the mean percentage of damage done to all varieties in full bloom at any given time, which indicates very conclusively that varieties which were in full bloom from the 1st to the middle of July are by far the worst damaged by the legume pod moth.

TABLE II.—*Mean percentage of damage done by the legume pod moth to all plats in full bloom on a given date in the season of 1910.*

Date of full bloom.	Mean per cent of seed damaged.	Number of plats.	Date of full bloom.	Mean per cent of seed damaged.	Number of plats.
June 16	0.1	1	July 1	0.2	7
June 17	.1	2	July 3	2.1	2
June 21	.0	3	July 6	1.1	15
June 23	.1	3	July 9	2.5	8
June 24	.3	2	July 12	2.3	1
June 25	.0	1	July 14	5.1	2
June 26	.4	6	July 17	1.1	1
June 28	.3	1	July 24	1.3	1
June 30	1.0	6			

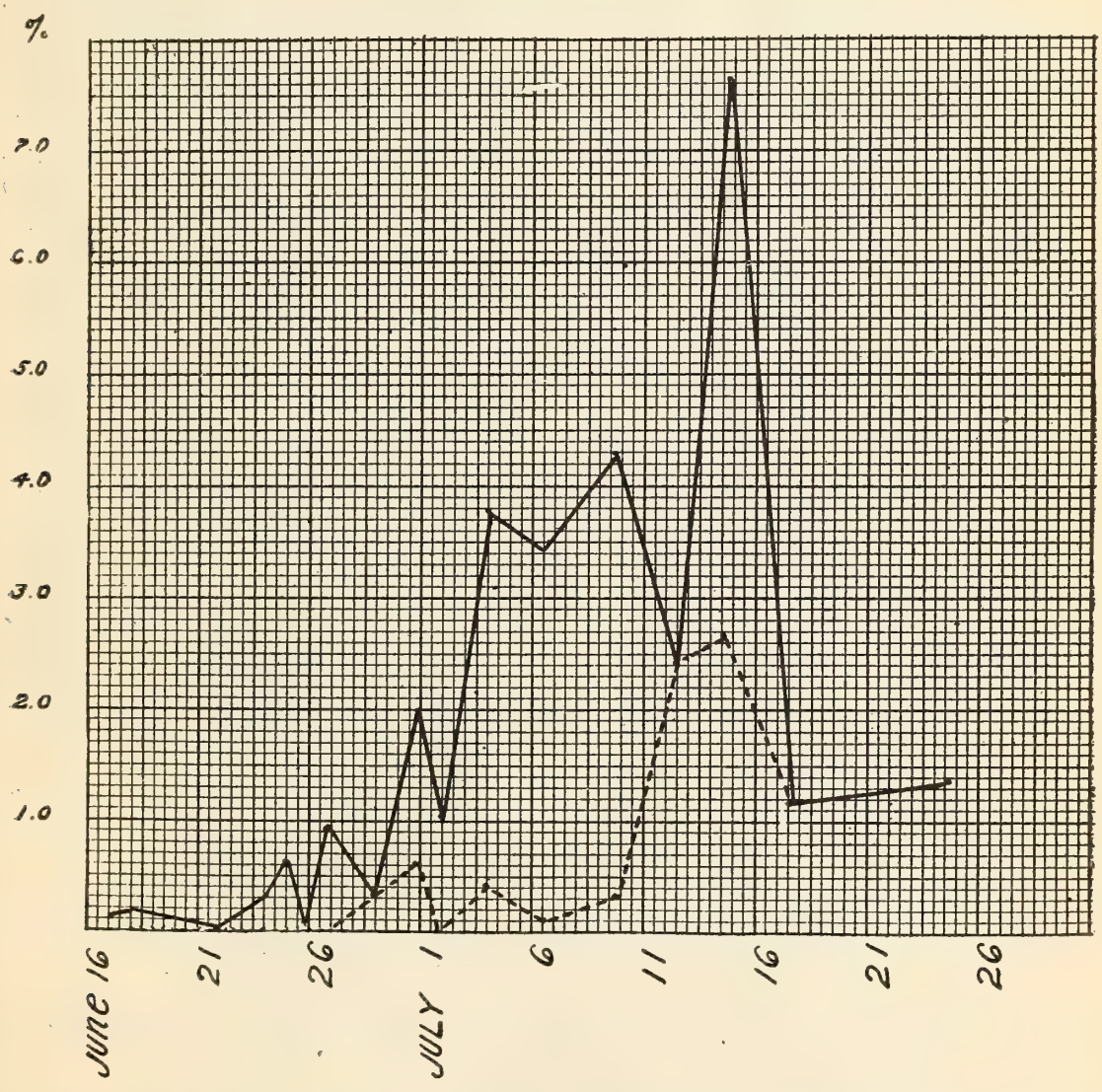


FIG. 36.—Diagram showing maximum and minimum damage done by the legume pod moth to varieties of peas in full bloom on a given date in 1910. (Original.)

EXPERIMENTAL WORK CARRIED ON DURING THE SEASON OF 1911.

Sixty-seven varieties of field peas were planted in 1911 on the farm of the State College at Pullman, Wash. The field selected was in a draw, or ravine, bordered on three sides by grain fields and on

the fourth side by a clean cultivated orchard. The plats were 1 square rod in area, as they were the year before, and separated from each other by strips of oats 1 yard wide. Two plats of each variety were planted side by side. (See fig. 39.) Plate X shows a part of the experimental plats used this season. The moths were not quite so destructive this season as last, 2.5 per cent being the greatest damage done to any variety this year, while in 1910 as high as 7.6 per cent

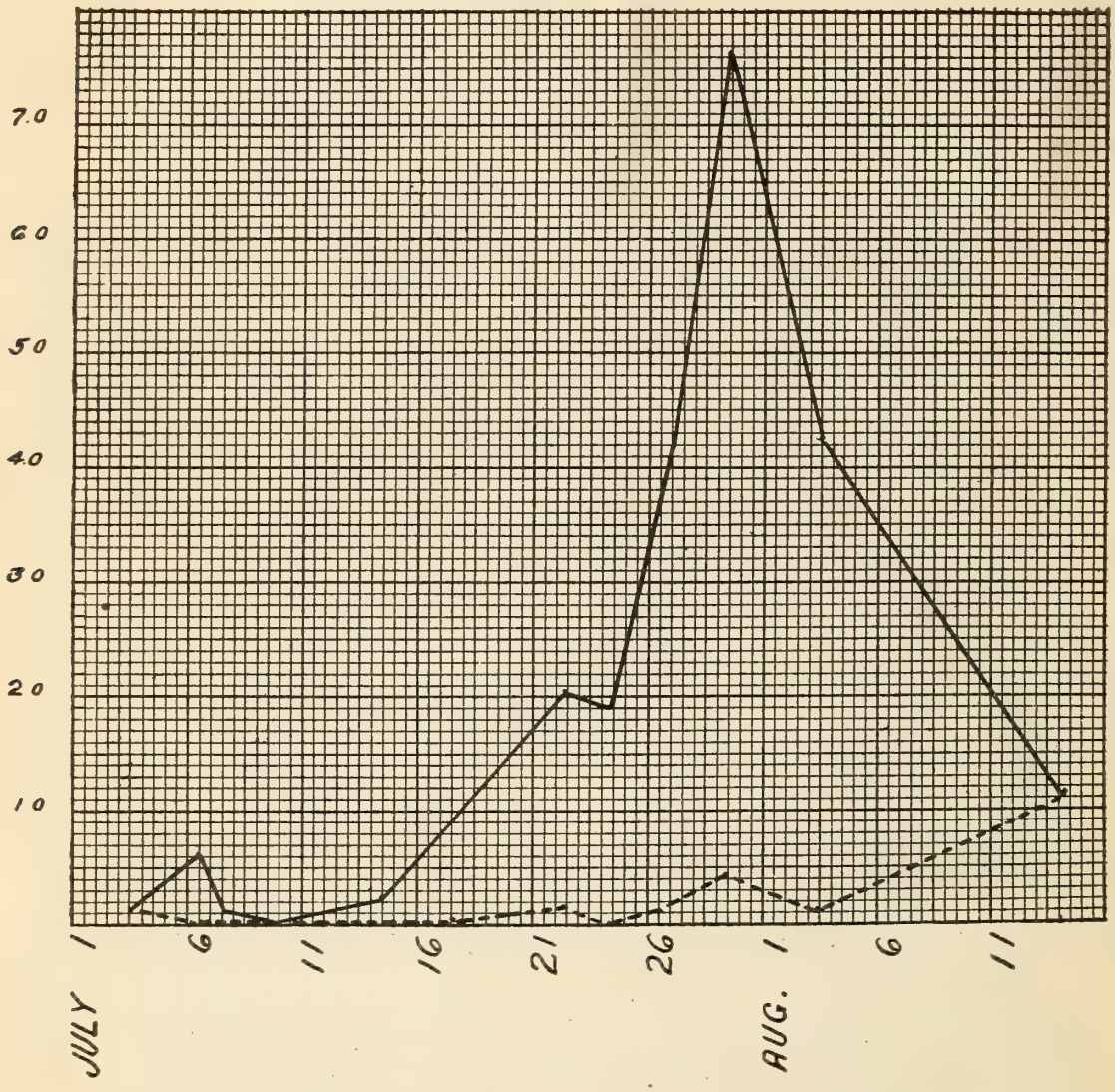
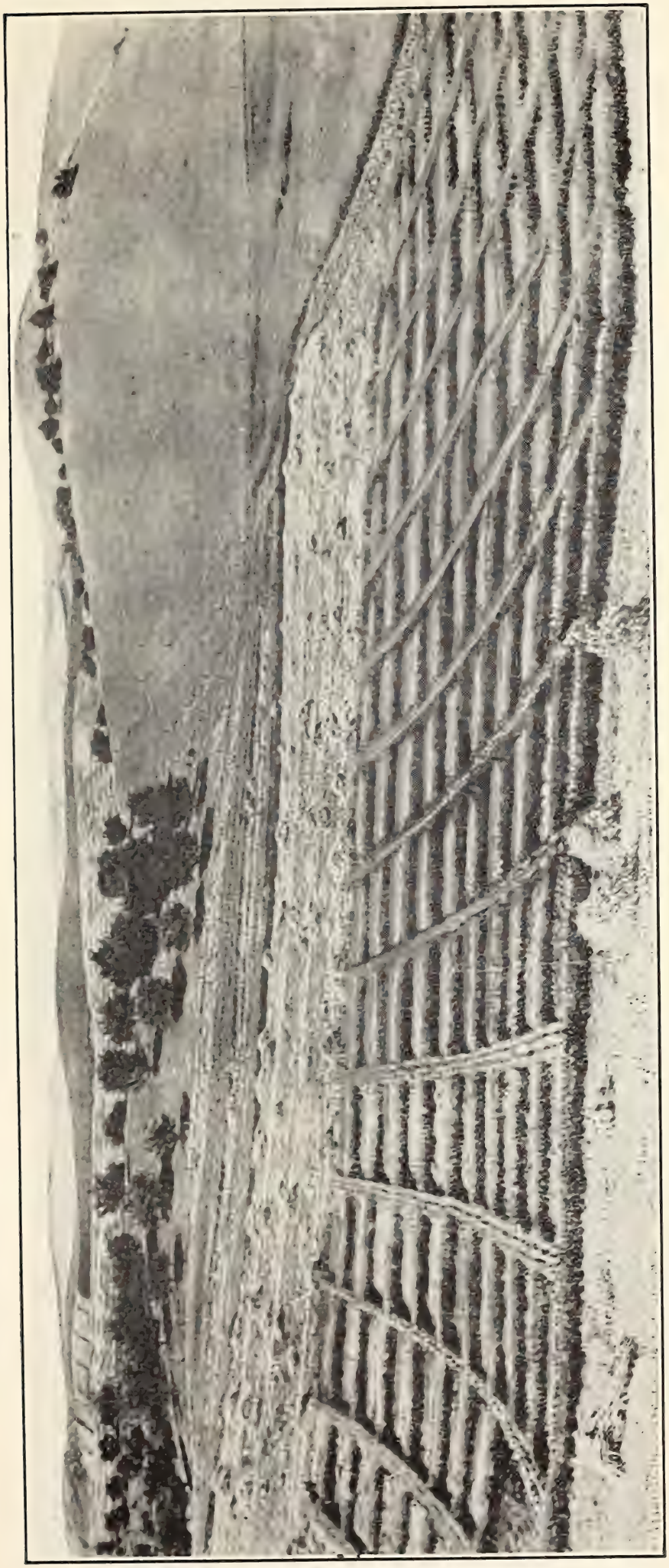


FIG. 37.—Diagram showing maximum and minimum damage done by the legume pod moth to varieties of peas which ceased to bloom on a given date in 1910. (Original.)

of one variety was destroyed. However, the results obtained are as conclusive as those recorded last year.

Table III gives the data of this season's work and is self-explanatory. Table IV is arranged to show the mean percentage of damage done to all plats which came into full bloom on any one date. Figure 40 graphically illustrates these results and very clearly shows that varieties which were in full bloom prior to June 28 were practically unmolested.



EXPERIMENTAL PLATS USED IN INVESTIGATIONS OF THE LEGUME POD MOTH DURING THE SEASON OF 1911. (ORIGINAL.)

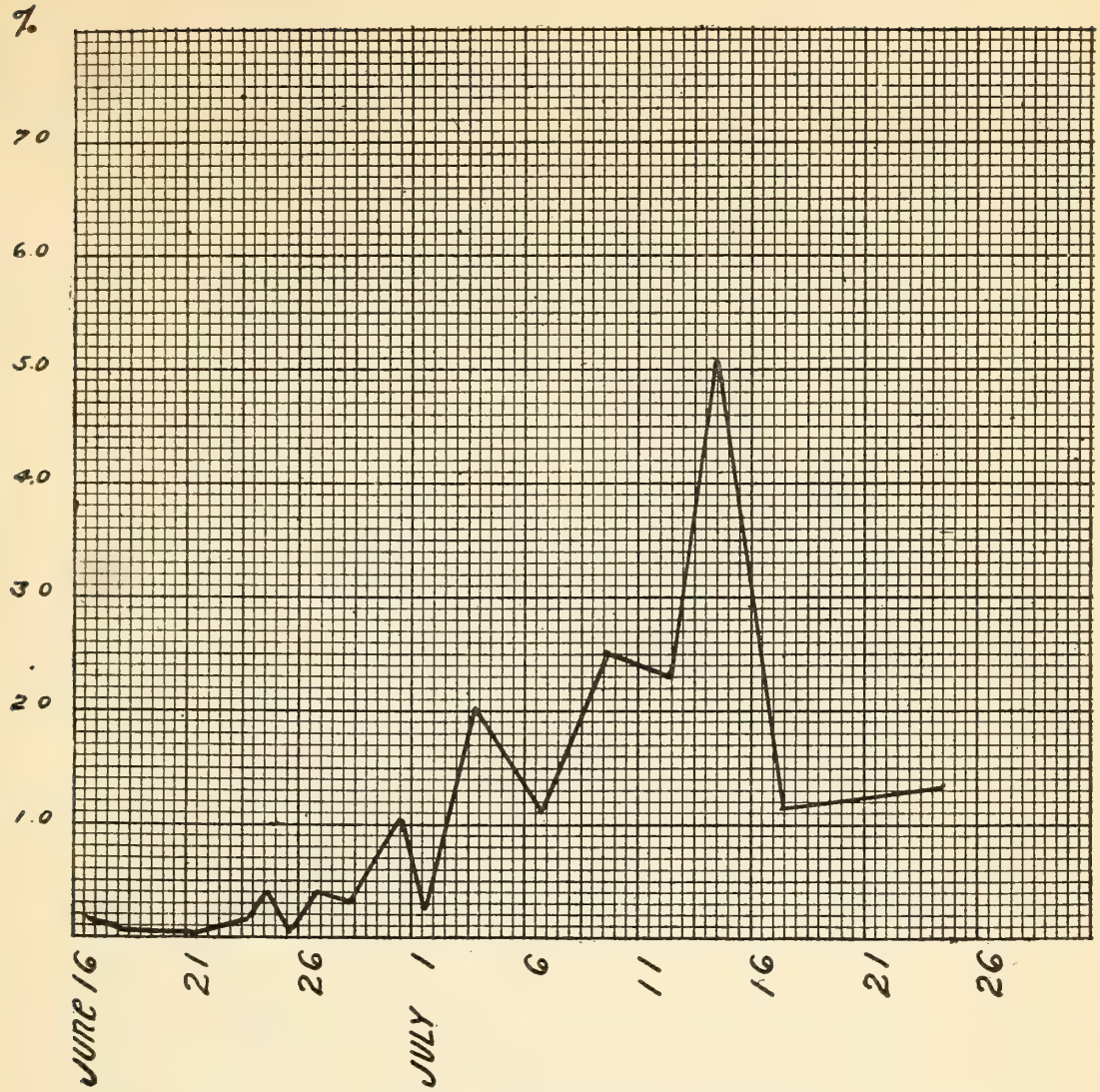


FIG. 38.—Diagram showing mean percentage of damage done by the legume pod moth to varieties of peas in full bloom on a given date in 1910. (Original.)

10	10	11	11	30	30	31	31	50	50	51	51		
9	9	12	12	29	29	32	32	49	49	52	52		
8	8	13	13	28	28	33	33	48	48	53	53		
7	7	14	14	27	27	34	34	47	47	54	54	67	67
6	6	15	15	26	26	35	35	46	46	55	55	66	66
5	5	16	16	25	25	36	36	45	45	56	56	65	65
4	4	17	17	24	24	37	37	44	44	57	57	64	64
3	3	18	18	23	23	38	38	43	43	58	58	63	63
2	2	19	19	22	22	39	39	42	42	59	59	62	62
1	1	20	20	21	21	40	40	41	41	60	60	61	61

FIG. 39.—Planting plan of plats used in investigations of the legume pod moth during the season of 1911. (Original.)

TABLE III.—*Record of experimental work on the legume pod moth for the season of 1911.*

Plat No.	B. P. I. No.	Date of planting.	Began blooming.	Full bloom.	Blooming ended.	Total number of seed.	Number of seed damaged.	Per cent damaged.
1	24895	Apr. 15	June 17	June 28	July 15	9,400	0	0.0
2	29366	...do.....	June 7	June 12	July 7	33,529	0	.0
3	22639	...do.....	June 16	June 19	July 15	23,797	5	.0
5	18806	...do.....	...do.....	...do.....	July 7	2,279	2	.0
12	29368	Apr. 17	June 22	June 28	July 15	28,417	7	.0
38	22638	Apr. 18	June 12	June 16	...do.....	19,899	4	.0
57	21288	...do.....	June 19	June 28	...do.....	22,462	8	.0
65	3182	...do.....	June 22	...do.....	...do.....	15,745	9	.0
4	17483B	Apr. 15	June 25	July 8	July 30	18,725	20	.1
8	23850	...do.....	June 16	June 28	July 21	16,380	18	.1
14	23547	Apr. 17	June 22	...do.....	July 15	19,725	21	.1
6	22540	Apr. 15	June 19	July 8	July 21	10,290	24	.2
21	23290D	Apr. 17	...do.....	July 3	July 15	22,823	46	.2
9	22044	Apr. 15	June 28	July 15	Aug. 1	14,463	104	.7
17	22043	Apr. 17	...do.....	July 13	July 29	8,416	68	.8
20	23414	...do.....	June 26	July 7	July 15	16,279	131	.8
30	29372	...do.....	June 19	June 28	...do.....	8,726	88	1.0
52	23290H	Apr. 18	June 28	July 10	...do.....	8,909	90	1.0
58	19389	...do.....	June 22	July 7	...do.....	10,080	101	1.0
10	17486	Apr. 15	June 28	...do.....	July 21	13,772	161	1.1
13	29365	Apr. 17	July 12	July 15	Aug. 1	21,795	242	1.1
39	25439	Apr. 18	June 28	July 7	July 21	20,224	223	1.1
56	24179	...do.....	June 19	July 1	July 10	13,406	148	1.1
62	11097	...do.....	...do.....	June 28	...do.....	31,369	377	1.2
59	24940	...do.....	June 22	July 5	July 15	22,259	268	1.2
54	23290E	...do.....	June 28	July 7	July 21	24,165	290	1.2
51	22049	...do.....	.....	July 15	...do.....	12,514	151	1.2
47	21709	...do.....	June 22	June 28	July 15	3,235	42	1.3
48	22077	...do.....	June 12	...do.....	...do.....	14,303	201	1.4
34	16130	Apr. 17	June 28	July 8	July 26	22,857	320	1.4
44	16436A	Apr. 18	.....	July 7	July 21	10,226	154	1.5
22	22037	Apr. 17	July 12	July 15	Aug. 1	19,761	299	1.5
23	17483	...do.....	July 7	July 13	July 30	12,814	193	1.5
63	11112A	Apr. 18	June 16	July 7	July 23	13,164	211	1.6
19	17006	Apr. 17	July 7	July 12	July 21	14,352	243	1.7
43	22042	Apr. 18	...do.....	July 15	Aug. 1	11,828	201	1.7
26	22046	Apr. 17	.....	...do.....	July 30	13,141	224	1.7
16	29369	...do.....	June 26	July 7	July 15	10,112	184	1.8
31	2203	...do.....	July 7	July 13	July 21	15,373	277	1.8
35	22036	...do.....	June 26	July 7	...do.....	20,868	376	1.8
67	11112	Apr. 18	June 19	...do	July 15	16,234	294	1.8
28	29367	Apr. 17	June 24	...do.....	...do.....	9,399	188	2.0
42	21290	Apr. 18	...do.....	July 5	...do.....	14,588	292	2.0
33	29371	Apr. 17	June 28	July 7	July 21	26,239	527	2.0
46	25917	Apr. 18	July 7	July 15	...do.....	22,859	457	2.0
66	3179	...do.....	.....	July 10	July 26	13,599	272	2.0
61	22048	...do.....	July 7	July 15	Aug. 1	19,140	383	2.0
11	22639A	Apr. 17	June 28	July 7	July 21	9,277	199	2.1
18	17483F	...do.....	July 12	July 15	...do.....	15,379	323	2.1
24	29323	...do.....	June 22	July 7	July 15	13,528	285	2.1
27	19786	...do.....	.....	...do.....	July 25	10,621	223	2.1
36	27003	...do.....	July 7	July 13	July 26	22,266	468	2.1
40	16437A	Apr. 18	June 28	July 7	July 21	8,776	185	2.1
53	12887	...do.....	...do.....	...do.....	July 15	29,165	613	2.1
60	22041	...do.....	July 7	July 13	July 25	20,366	428	2.1
55	29370	...do.....	...do.....	July 15	...do.....	7,333	162	2.2
49	23847	...do.....	...do.....	...do.....	July 21	18,206	401	2.2
45	20467	...do.....	June 28	July 7	...do.....	14,602	322	2.2
25	19788	Apr. 17	July 7	July 15	Aug. 1	11,209	259	2.3
50	27004	Apr. 18	...do.....	...do.....	July 27	10,370	239	2.3
64	3184	...do.....	June 28	July 5	July 15	14,933	359	2.4
41	22040	...do.....	July 7	July 13	July 21	16,498	397	2.4
15	17483C	Apr. 17	...do.....	July 15	Aug. 1	1,871	45	2.4
32	26819	...do.....	.....	July 18	...do.....	24,470	612	2.5
29	19787	...do.....	July 7	July 15	...do.....	15,473	387	2.5
7	19709	July 15	.....	...do.....	...do.....	7,506	192	2.6
37	16436C	July 18	June 28	July 7	July 21	21,791	557	2.6

TABLE IV.—*Mean percentage of damage done by the legume pod moth to all plats in full bloom on a given date in the season of 1911.*

Full bloom.	Mean per cent of seed damaged.	Number of plats.	Full bloom.	Mean per cent of seed damaged.	Number of plats.
June 12	0.0	1	July 7	1.7	19
June 16	.0	1	July 8	.6	3
June 19	.0	2	July 10	1.5	2
June 28	.5	10	July 12	1.7	1
July 1	1.1	1	July 13	1.8	6
July 3	.2	1	July 15	1.9	15
July 5	1.9	3	July 18	2.5	1

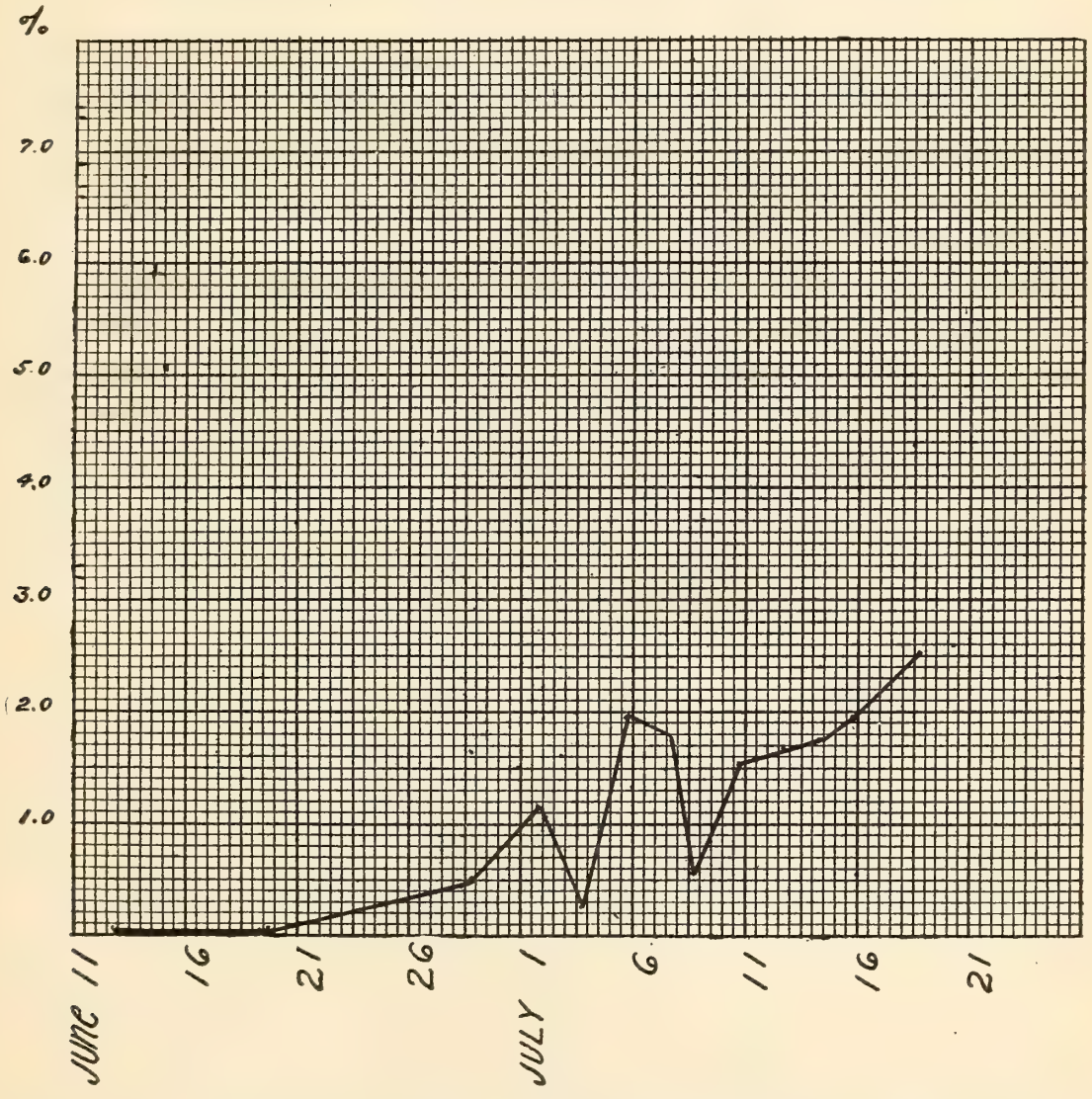


FIG. 40.—Diagram showing mean percentage of damage done by the legume pod moth to varieties of peas in full bloom on a given date in 1911. (Original.)

ARTIFICIAL DISSEMINATION.

On examining sacks of seed peas, September 14, 1911, a larva was found enclosed in a very tough silken cocoon. On October 24 another larva was found in a second sack. Mr. Evans also found a hibernating larva in a seed sack and kept it alive on his desk during the greater part of the winter. It seems as if this insect could very easily be introduced into regions where it does not at present occur, by being shipped with the seed field peas.

PARASITES.

Two hymenopterous parasites were reared from the larvæ of *Etiella zinckenella schisticolor* during the investigations at Pullman, Wash., viz, *Pseudapanteles etiellæ* Vier. and *Microbracon hyslopi* Vier.

Dr. F. H. Chittenden [1] records having reared *Bracon* sp. (determined by Viereck) from *Etiella schisticolor* on October 19, 1908, at Santa Ana, Cal., and Mr. C. L. Marlatt [2] records rearing a braconid from the larva of this moth at Nuecestown, Tex., on May 13, 1896.

REMEDIAL AND PREVENTIVE MEASURES.

The legume pod moth is readily controlled by preventive measures, and for this reason there have been no experiments with remedies. The transportation of the hibernating forms in sacks of seed, and the consequent dissemination of the pest, may be prevented by fumigation of the seed with carbon bisulphid.

Owing to the presence of the native lupines, extermination of the pest is impossible, but by planting such early varieties of field peas as come into full bloom before the last week in June it may be practically eliminated as a factor to be dealt with in seed growing in the Pacific Northwest. The date of planting, however, will vary in different localities and under different conditions.

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[1] Bul. 82, Pt. III, Bur. Ent., U. S. Dept. Agr., p. 28, 1909.

[2] Bureau of Entomology Notes, No. 7044.

THE LEGUME POD MAGGOT.

(*Pegomya planipalpis* Stein.)

By James A. Hyslop,
Agent and Expert.

GENERAL ACCOUNT.

About the middle of July, 1909, a large number of larvæ of *Pegomya planipalpis* Stein were found leaving the pods of lupines that had been placed in rearing cages. On the 28th two pupæ were found in one of the cages. Within the next few days many more larvæ left the pods and pupated. A number of these puparia placed in a glass vial during the autumn of 1910 were kept in the field laboratory all winter. May 11 of the following year the first adult emerged and from that date others emerged daily throughout the remainder of the month. By a number of experiments it was found that humidity greatly facilitated the emergence of these flies.

These flies were first believed to be scavengers, feeding on the frass and decaying seed of the lupine and field peas in the wake of the legume pod moth. However, investigations in 1910 proved that the insect, though often found with Etiella, was quite capable of independently infesting seed pods and was itself an actual seed destroyer. Many pods were found to contain from one to three of these larvæ.

Dr. F. H. Chittenden,[1] of this bureau, notes this species as attacking radishes at San Francisco, Cal.

The larvæ molt at least twice, as two pairs of pharyngeal hooks were found in a pod with one larva. Though several of these dipterous larvæ were found in field-pea pods with the head capsules of larvæ of the legume pod moth, we hardly believe this species to be parasitic, as larvæ confined in small vials with pod-moth larvæ would not attack the latter.

In cages with earth in the bottom the pupæ were always to be found below the surface at distances ranging from 1 to 3 inches. The larvæ contract just before forming a puparium. The puparium is at first creamy yellow, turning brown at the ends first and finally becoming entirely ferruginous. A larva that contracted on the morning of July 31, 1911, assumed the usual puparium form by 9.30 a. m. of the same day. It was still pale yellow, but by 2.30 p. m. it had become brownish at the ends and deep orange-yellow at the middle, while next morning the puparium was uniformly ferruginous brown.

[1] Bul. 66, Pt. VII, Bur. Ent., U. S. Dept. Agr., p. 95, 1909.

DESCRIPTION.

THE LARVA.

(Fig. 41.)

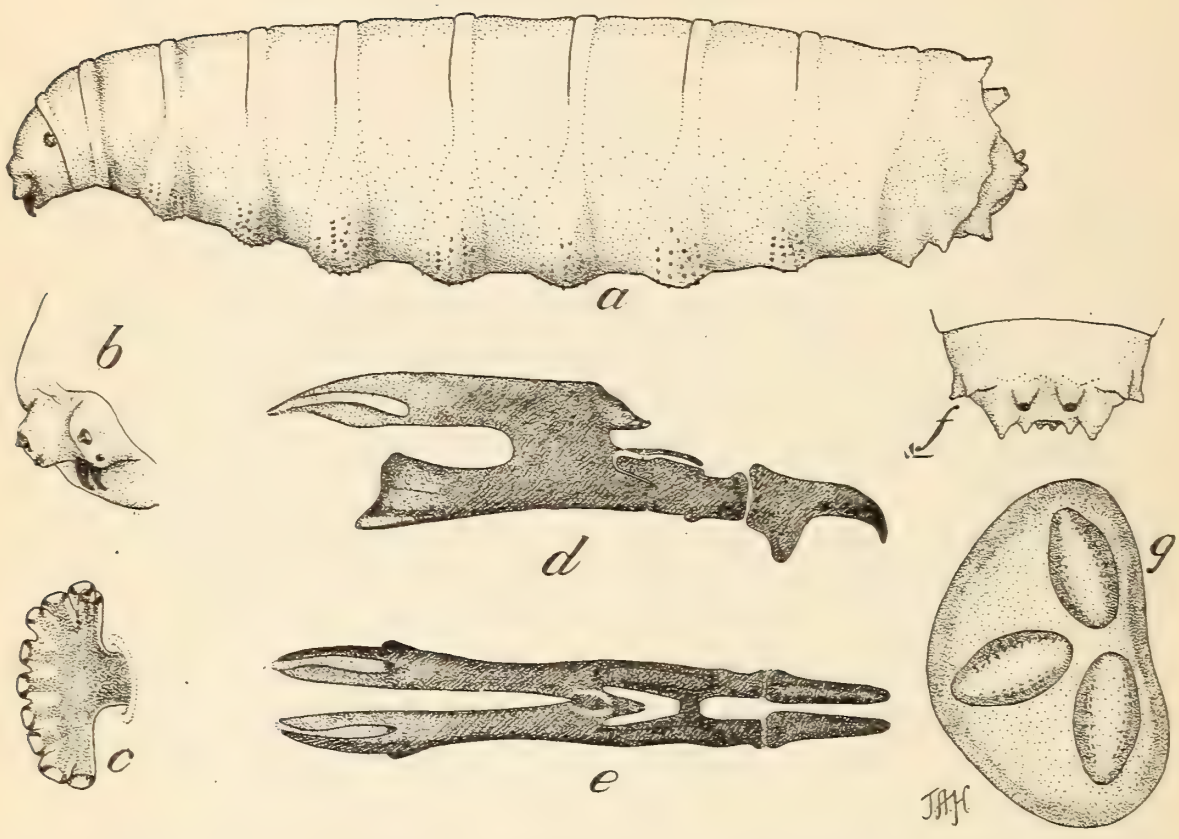

FIG. 41.—The legume pod maggot (*Pegomya planipalpis*). Larva: *a*, Side view; *b*, oblique aspect of head; *c*, thoracic spiracle; *d*, *e*, pharyngeal hooks, lateral and dorsal aspect; *f*, dorsal aspect of caudal segment; *g*, anal spiracle. *a*, Much enlarged; *b–g*, highly magnified. (Original.)

Larva cream-white, 7.9 mm. in length and 1.9 mm. in diameter. Broadly blunt posteriorly, conically tapering to anterior end. Hook jaws black. At base of second thoracic segment a pair of fan-shaped thoracic spiracles which are pale yellow and ten-lobed. Anal spiracles on rather long papilliform tubercles; spiracular orifices of each spiracle three in number and arranged to form a letter T, the stem directed laterad and slightly ventrad. Four small tubercles below the spiracles are arranged in a row across the end of the caudal segment, the outer pair the larger. In front and to the side of this row is a pair of larger tubercles and in front of this pair is a ring of twelve tubercles around the segment; the two dorso-lateral and the two ventro-lateral tubercles large and conspicuous, the others smaller. Ventral swellings on segments 3 to 9, inclusive, armed with many small spinous papillæ.

FIG. 42.—The legume pod maggot: Puparium. Much enlarged. (Original.)

THE PUPARIUM.

(Fig. 42.)

Puparium ferruginous, dark brown at ends. Cylindrically oval, finely wrinkled. Hook jaws of larva visible. Length 6.4 mm.; width 2.3 mm.

THE PUPA.

(Fig. 43.)

White, head large, front protruding. Legs and wing pads free. Third pair of legs under wing pads except tarsi.

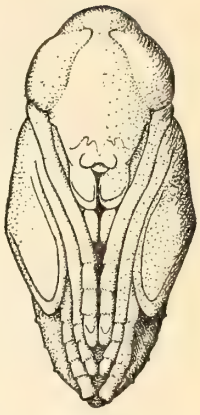

FIG. 43.—The legume pod maggot: Pupa. Much enlarged. (Original.)

THE ADULT.

(Fig. 44.)

The following is a translation of the original description by P. Stein, published in the Berliner Entomologische Zeitschrift, volume 42, page 234, 1897.

Pegomya (*Chortophila*) *planipalpis*. ♂ ♀. Size, shape, and color similar to *Ch. cilicrura* Rd. Cinereous; eyes cohering closely on inside, frontal triangular stripe practically straight, reddish; front and epistoma laterally moderately prominent, cinereo-rufous, peristome moderately broad, grayish; antennæ black, third joint twice as long as second, base of arista thickened, very slightly pubescent,

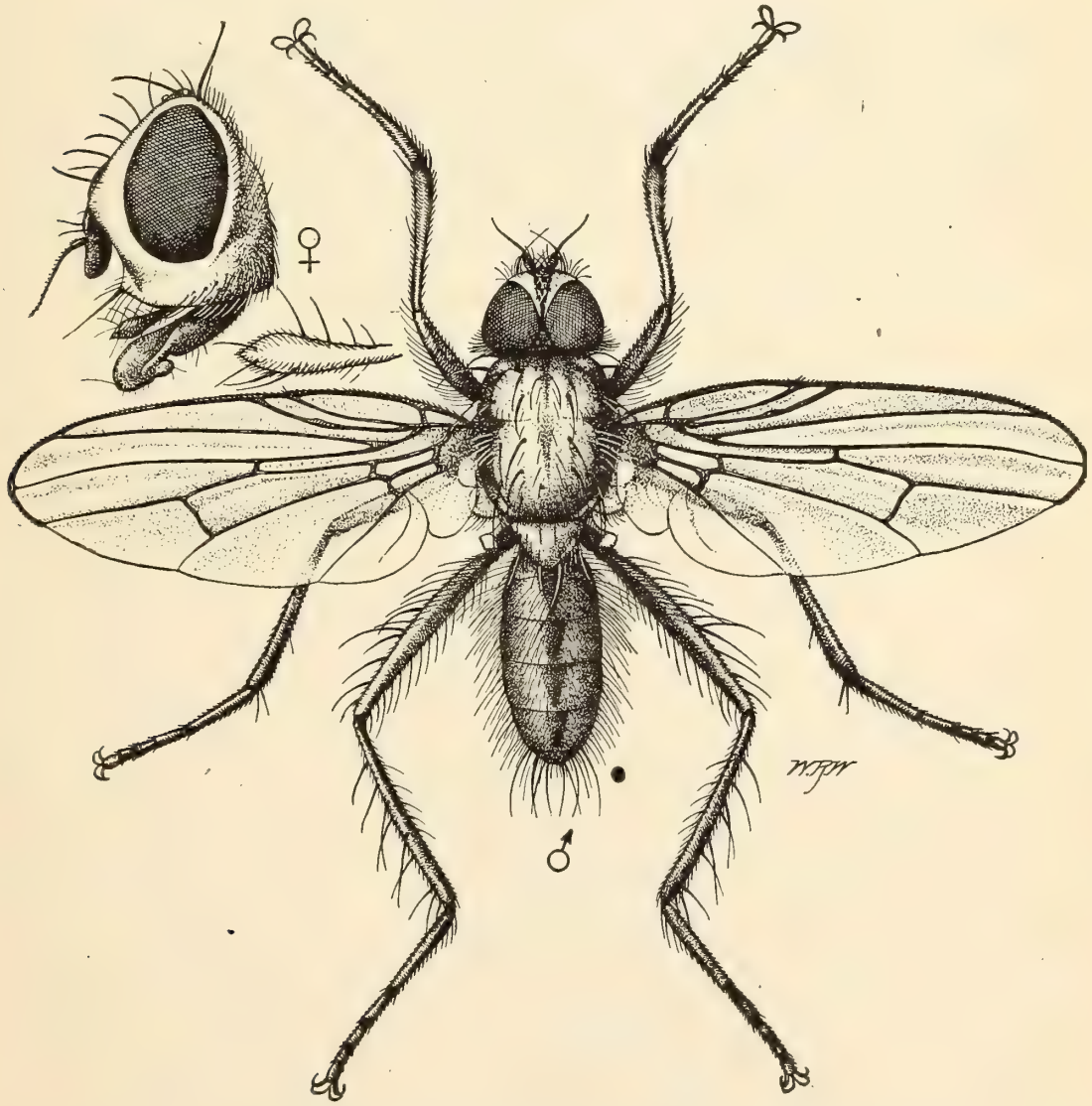

FIG. 44.—The legume pod maggot: Adult male, enlarged; side of head of female, much enlarged. (Original).

palpi black, apex a little dilated; thorax cinereous, less so on the sides, median line narrow and lateral stripes hardly perceptibly wider; abdomen elongate, depressed, median stripe and incisures narrowly black; tarsi black; pulvilli and ungues, the

anterior ones moderately and the posterior one slightly, elongate; wings nearly hyaline, longitudinal veins 3 and 4 parallel, anterior cross-vein perpendicular and nearly straight, costal spines small; squamæ equal and white, halteres yellowish. Female yellowish-gray; eyes with frontal stripe broad, dirty reddish, and quite broadly separated with yellowish gray; palpi distinctly dilated at apex; thorax nearly immaculate; abdomen oblong, median stripe and small areas shining indistinct yellowish brown; base of wings yellowish. Size ♂ 5, ♀ 6 mm.

PARASITES.

Pegomya planipalpis is attacked by two chalcidid parasites. One (*Holaspis* n. sp.) belongs to a genus of which there are two known species, *Holaspis parellina* Boh. and *H. papaveris* Thoms., recorded [1] as parasitic on *Cecidomyia* spp. The other parasite (not yet determined) reared from the legume pod maggot is probably also new to science.

REMEDIAL AND PREVENTIVE MEASURES.

This maggot has not as yet become a serious factor in field-pea seed growing in the Pacific Northwest. The dissemination as hibernating puparia can be readily prevented by fumigation. As is the case with the legume pod moth, it can not be exterminated because of the native lupines.

[1] Dalla Torre, Catalogus Hymenopterorum, vol. 5, p. 291, 1898.

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U. S. D. A., B. E. Bul. 95, Part VII. Issued October 16, 1912.

PAPERS ON CEREAL AND FORAGE INSECTS.

THE ALFALFA LOOPER IN THE PACIFIC NORTHWEST.

(*Autographa gamma californica* Speyer.)

By J. A. Hyslop,
Agent and Expert.

INTRODUCTION.

The first record of this moth of economic importance is an unpublished note by Mr. Theodore Pergande[1] made June 29, 1895, wherein he records having received from Mr. E. W. Baker, of Grand Junction, Colo., a few specimens of the larvæ of a Plusia, determined on the note as "*Plusia gamma* (?)," with the statement that the larvæ do much damage to the leaves and blossoms of alfalfa. Material was not preserved, so actual specific determination is impossible. As *Plusia gamma* L. is a European species, presumably it was *P. gamma californica* Speyer, now known as *Autographa gamma californica.*

The depredations of this species have not as yet been sufficiently serious to cause damage in the Palouse region of Washington and Idaho, although its attacks on alfalfa and clover have attracted the attention of many ranchers. The larvæ are usually very numerous in the early spring and gradually increase in numbers until the first hay cutting, when they appear to reach the maximum. They do not seem to be inconvenienced by the removal of the hay crop, but immediately turn their attention to the young second growth, on which larvæ are to be found throughout the summer until the early frosts.

The alfalfa looper in this locality has been held in check by a number of parasites and a disease, but any change in environmental conditions which might tend to reduce the efficiency of these natural checks or accelerate the reproduction of these moths would undoubtedly cause a serious outbreak, such as occurs periodically with the highly parasitized white-marked tussock moth, *Hemerocampa leucostigma* S. & A. It does, however, offer an excellent illustration of the statement, so often made, that many injurious insects are held in check by their parasites. Such cases as the above justify the arti-

[1] Bureau of Entomology Notes, No. 6692.

ficial introduction of parasites as one of the efficient measures to be taken in the control of a serious pest.

That *Autographa gamma californica* may appear in enormous numbers is evidenced by one of the earliest biological records on this species. A note in the Bureau of Entomology files, made by Mr. Koebele[1] in 1886, states that on the morning of April 30 he examined a mass of material collected from within an electric light globe at Los Angeles, Cal. Of 4,161 moths examined, 2,005 were *Autographa gamma californica*. He further states that the larvæ were numerous on a variety of plants. In anticipation of such an outbreak the biological notes and other data at hand in this office are herewith published.

DISTRIBUTION.

Specimens of this moth (*Autographa gamma californica*) in the United States National Museum were collected in Los Angeles County, Kern County, Placer, Alameda, and Fresno, Cal.; Colorado; Nevada; Seattle, Pullman, and Easton, Wash.; and along Kaslo Creek, in British Columbia. Mr. T. H. Parks, of this office, has collected larvæ of this species at Cokeville, Wyo., and Idaho Falls and Blackfoot, Idaho, in all cases feeding on alfalfa.

SEASONAL HISTORY.

This insect, in the Palouse region of Washington, passes the winter as hibernating pupa and probably also as the adult moth, since much-battered adults are to be seen early in the spring. Late in May and throughout June the adults are to be seen in the alfalfa and clover, darting rapidly away when disturbed. They are active in bright sunlight, feeding on the nectar from the clover and alfalfa blossoms. The flight, though short, is very direct and so rapid as to render the insect almost invisible.

May 2, 1887, Mr. Koebele[1] records observing one of these moths, at Alameda, Cal., ovipositing on *Malva rotundifolia* at 3 o'clock in the afternoon. Definite data relative to the length of the egg stage of this species have not been obtained, though several female moths were confined for that purpose. They fed greedily on sugar sirup but refused to oviposit. However, Mr. E. O. G. Kelly, of this bureau, captured a female of *Autographa brassicæ* Riley in an alfalfa field at Wellington, Kans., on October 27, 1909. This moth died the following day, after laying eight eggs. These began hatching on November 2 and were all hatched the next day. This limits the egg stage of *Autographa brassicæ* to seven days, and this is very likely the time of incubation of the other species of this genus.

[1] Bureau of Entomology Notes, No. 95 K.

Early in June the young larvæ become numerous in the fields, walking very much as do geometrid larvæ or "measuring worms." This is due to the fact that the larvæ have prolegs on only the fifth, sixth, and ninth abdominal segments. If disturbed they curl up and drop to the ground, the older larvæ lying there tightly curled up and refusing to move when irritated, but larvæ of the second and third instars when touched alternately straighten out and curl up very suddenly, thus jumping about spasmodically. The larvæ while young feed upon the epidermis of the leaves, skeletonizing them and giving to the attacked plant a brownish appearance. The older larvæ—that is, after the third molt—eat from the edge of the leaf toward the midrib, entirely consuming the leaves. The larval period lasts about two weeks, there being five molts with periods of about three days elapsing between each. When ready to pupate the larva spins a loose white silken cocoon (Pl. XI, fig. 2) among a number of leaves, usually well up in the plants, incorporating two or three leaves in its structure. The larva completes the cocoon in about half a day and, at least in the case of specimens reared in our insectary, pupates the day following that on which the cocoon is completed. The length of the pupal stage of specimens reared in our laboratory was very uniformly 10 or 11 days. Dr. H. G. Dyar[1] gives 12 days as the length of this period, and Mr. Koebele[2] records the length of the pupal stage as from 10 to 15 days. He gives an exact rearing record[3] wherein he mentions a larva collected at Piedmont, Cal., February 24, 1888, which pupated on March 5, the moth emerging March 22, making a pupal period of 17 days. Dr. F. H. Chittenden, of this bureau, gives from 6 to 22 days as the pupal period of a closely related species, *Autographa brassicæ*.

Thus the time elapsing from egg laying until the adult emerges covers a period of from 26 to 48 days, probably being about 30 days in the Palouse country of Washington.

The first adults of the second generation appear in early July, and adults continue quite numerous throughout this month, belated individuals having been collected as late as August 3. There are two generations, and probably three in the case of the earlier appearing individuals, and larvæ in all instars are to be found in the field as late as the end of August, but these very late larvæ probably succumb during the winter.

Mr. T. H. Parks, of this office, records finding the larvæ of this species about half grown in the alfalfa fields about Salt Lake City, Utah, as early as May 22, in 1911. Larvæ were found throughout June. The first pupa found in this locality was obtained on June 5

[1] Entomologica Americana, vol. 6, p. 14, 1890.
[2] Bureau of Entomology Notes, No. 95 K.
[3] Bureau of Entomology Notes, No. 389 K.

from a larva in one of the rearing cages. Mr. Parks records obtaining an adult in his cages on July 7, and observed another adult in the alfalfa fields near the Salt Lake City Field Laboratory on August 2. On August 23 one of these moths was found under a board lying along a fencerow adjoining an alfalfa field near Salt Lake City.

FOOD PLANTS.

Mr. Koebele[1] records the larva of this species as feeding on cabbage, barley, and elder (*Sambucus* sp.) at Los Angeles, Cal.; on dock (*Rumex* sp.) at Piedmont,[2] Cal., and records collecting a female while ovipositing and also larvæ while feeding on *Malva rotundifolia* at Alameda, Cal. We have collected the larvæ and reared adults from red clover, alfalfa, and garden peas at Pullman, Wash.

DESCRIPTIONS.

THE EGG.[3]

"Egg hemispherical, rounded at the base, the apex with a rounded depression. Finely creased vertically; color pale yellow."

THE LARVA.

First instar (?).—Body slender, pale creamy white, with long black hairs; head conspicuously large, shining black; thoracic legs blackish; only three pair of prolegs, situated on abdominal segments 5, 6, and 9, prolegs concolorous with body. Length, 1.8 mm.

Second instar.—Body segments 7 and 8 enlarged, 9 small; color pale green, marked with cream-colored longitudinal lines as follows: A subdorsal line, very fine and wavy; a stigmatal line, broader, straight, sharply defined dorsally, and fading out ventrally; segments ornamented with transverse row of black papillæ bearing black hairs; head cream-color; thoracic legs cream-color, with tips of claws ferruginous. Length, 3 mm. to 5 mm.

Third instar.—Body papillæ white, with black dots at base of hairs; three longitudinal lines in subdorsal space, the more dorsal one fine, clearly defined and wavy, the middle one broad and indistinct, and the third one about as fine as the first but less wavy; stigmata on first thoracic and first to eighth abdominal segments, pale, with oval black margins, that on eighth abdominal segment much larger than others; mandibles pale reddish brown; eyes with series of six black dots arranged in a ventrally directed semicircle near the base of the antennæ. Length, 6 mm. to 9 mm.

Fourth instar.—Body darker green, papillæ in two transverse rows, the papillæ of one row alternating with those of the other; head green, paler than body, mandibles and palpi brownish; thoracic legs infuscate; marginal hooks of prolegs ferruginous-brown. Length, 10 mm. to 14 mm.

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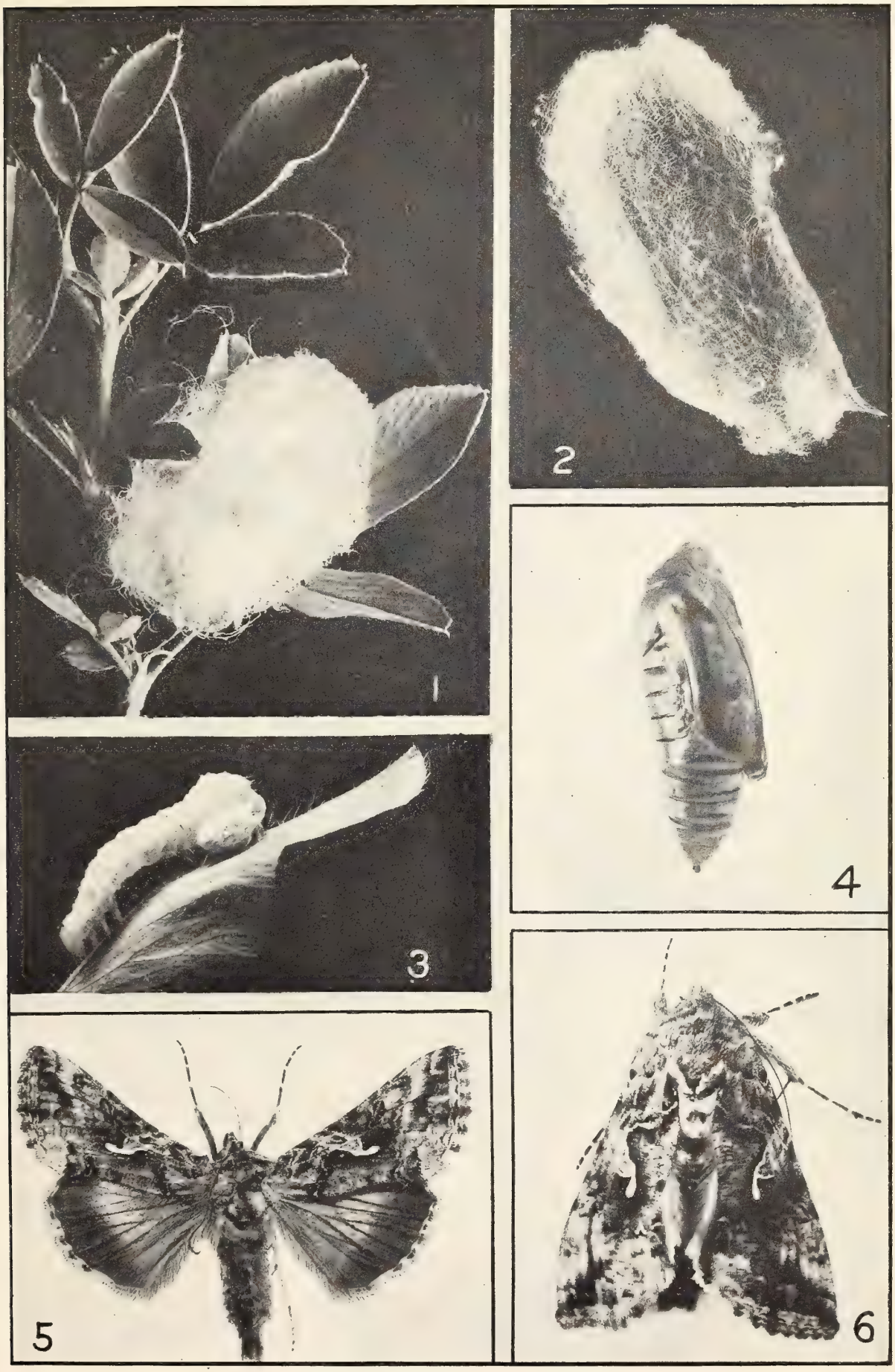
[1] Bureau of Entomology Notes, No. 95 K.
[2] Bureau of Entomology Notes, No. 389 K.
[3] Entomologica Americana, vol. 6, p. 14, 1890.



THE ALFALFA LOOPER AND ITS PARASITES.

Fig. 1.—Cocoon cluster of *Apanteles hyslopi*. Fig. 2.—Cocoon of alfalfa looper (*Autographa gamma californica*). Fig. 3.—Larva of alfalfa looper with cocoon of *Microplitis alaskensis*. Fig. 4.—Pupa of alfalfa looper. Fig. 5.—Adult alfalfa looper. Fig. 6.—Adult alfalfa looper at rest. All enlarged. (Original.)

Fifth instar (fig. 45).—Body dark olive-green, dorsal edge of stigmatal line opposed by an almost black line which fades into the general body color dorsally; head brilliant green, mandibles and palpi brown, a black oblong patch on posterior margin of eye extending from near median line almost to base of mandibles; thoracic legs almost black. Length, 21 mm. to 28 mm.

THE PUPA.

(Pl. XI, fig. 4.)

"Pupa depressed somewhat above the wing cases at back of the thorax, the eyes prominent, the tongue case projecting below the wing cases, forming a round prominence over the first abdominal segment. The cremaster is short and blunt, and the hooks with which it is furnished are fastened in the silk of the cocoon. Wing cases slightly creased. Color brownish-black, but paler at the joinings of the parts and between the abdominal joints. In occasional instances the whole pupa is pale."

The above description of the larval stages of this moth agrees in substance with that published by Dr. H. G. Dyar[1] for this species in California. The larvæ, however, are not constant in the matter of coloration. Adult larvæ were found without the characteristic black markings, while others had the entire head black. Some larvæ were of the same pale-green color in the fifth instar as in the fourth, while others were almost white.

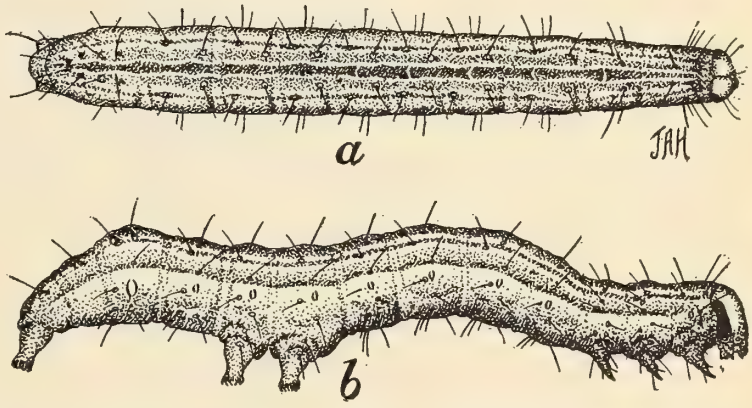


FIG. 45.—The alfalfa looper (*Autographa gamma californica*): *a*, Larva, dorsal aspect; *b*, same, lateral aspect. Enlarged 2½ diameters. (Original.)

That we had the first instar is only an assumption from the number of subsequent molts obtained. Dr. Dyar's description of the pupa is used, as it agrees identically with those found in the Northwest. The pupa is dark olive-green, with brown shadings and pale intersegmental bands when first formed, but soon becomes uniformly brown.

THE ADULT.[2]

(Pl. XI, figs. 5, 6.)

The following is a translation of Speyer's original description:

Two California males from Moschler's collections differ from the European *gamma* (which I can, however, only compare with native specimens) in the following points: The color of the dorsal surface of the forewings is a clear, light-blue gray, except the punctuation which is rose colored or rust colored; this is exhibited in all the *gamma* found here by me, and also in several distinct variations.

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[1] Entomologica Americana, vol. 6, p. 14, 1890.

[2] Stett. Ent. Zeit., vol. 36, p. 164, 1875; syn: *russea* Hy Edwards.

The *gamma* mark is somewhat differently shaped: Both its upper arms diverge, thus cutting off a broader equilateral triangle, through the upper median border, between them. The outer arm of this figure forms at its inner side an obtuse angle and is directed parallel with the hind edge (of the wing) while in the European species it is more basally directed. The lower arm of the *gamma* sign runs nearly horizontal. In this direction the black enclosed part, supported by the two outer arms, is more snout-shaped while in the German forms this form is approximately a rectangular space, rounded at its apex. The ring spot is surrounded by a whitish margin, elongate, and inclined very obliquely basally. The posterior diagonal band runs from the subcostal to the inner branch of the median (branch 2), not in a smooth curve as in *gamma* but in an unbroken straight line and is not so strongly curved basally opposite the lower arm of the *gamma* sign as in the latter. On the under surface, as in the French forms, the wings are clear white with, especially on the forewings, sharp black mottlings. The remainder of the border of the underside, as is also the color of the hind wings, is lighter colored than the European forms. This form may be easily separated from moderately light varieties in color and design by these important distinctions—the *gamma* sign and the posterior diagonal band.

Whether we have to do with a distinct species, a local variety, or merely an accidental variety, must be proved by more extensive comparisons.

Specimens of *gamma* from the Atlantic States, where they are said to be indigenous by Ruhordem, Koch, and Grote, I have not yet seen. They are, when the *californica* form is considered with them, spread over the whole northern hemisphere from Greenland to Abyssinia. They should be found even in New Holland [Australia], cf., my Geographical Distribution of the Butterflies of Germany, etc., Volume II, page 219.

PARASITES.

This moth is severely parasitized. At the field laboratory in Pullman, Wash., we obtained five hymenopterous and two dipterous parasites and observed a disease during the seasons of 1909 and 1910.

On July 12, 1909, two small larvæ of the alfalfa looper, measuring about 14 mm. in length, had contracted to 8 mm., became turgid, quite hard, and changed to a rich ferruginous brown. On July 22 of the same year two specimens of *Rhogas autographæ* Vier. (fig. 46) emerged. On close examination of this improvised puparium it is found to be almost entirely made up of the abdominal segments 7 to 12 of the lepidopterous larva (see fig. 47). The thoracic and anterior abdominal segments 1 to 6 contract to form an almost black annulated cap over one end of the puparium, with the transparent head shield terminating this cap. Segment 13, bearing the anal prolegs, terminates the other end of the puparium and is also transparent. Segments 9 and 10 each bear the transparent skin of their respective prolegs. The hair papillæ on segments 7 to 10 are pale and collected in a darker elevated band around the middle of their respective segments. The adult in emerging gnaws a smooth, circular hole through the dorsum of the eleventh and twelfth segments.

On July 29, 1909, a larva was observed with a cocoon fastened between the middle and anal prolegs (Pl. XI, fig. 3). The moth larva was still alive, though unable to move from the cocoon, and died the following day. On August 1 an adult hymenopteron, *Microplitis alaskensis* Ashm., emerged from this cocoon. The cocoon of this parasite (fig. 48, *c*) is pale green, 5 mm. long, cylindrically ovoid, and slightly pointed at the anterior end. In emerging the adult very neatly cuts a cap from the anterior end, this cap often remaining fastened to the cocoon by a few threads. On August 12 another larva was found bearing one of these cocoons, and on August 14 an adult parasite emerged.

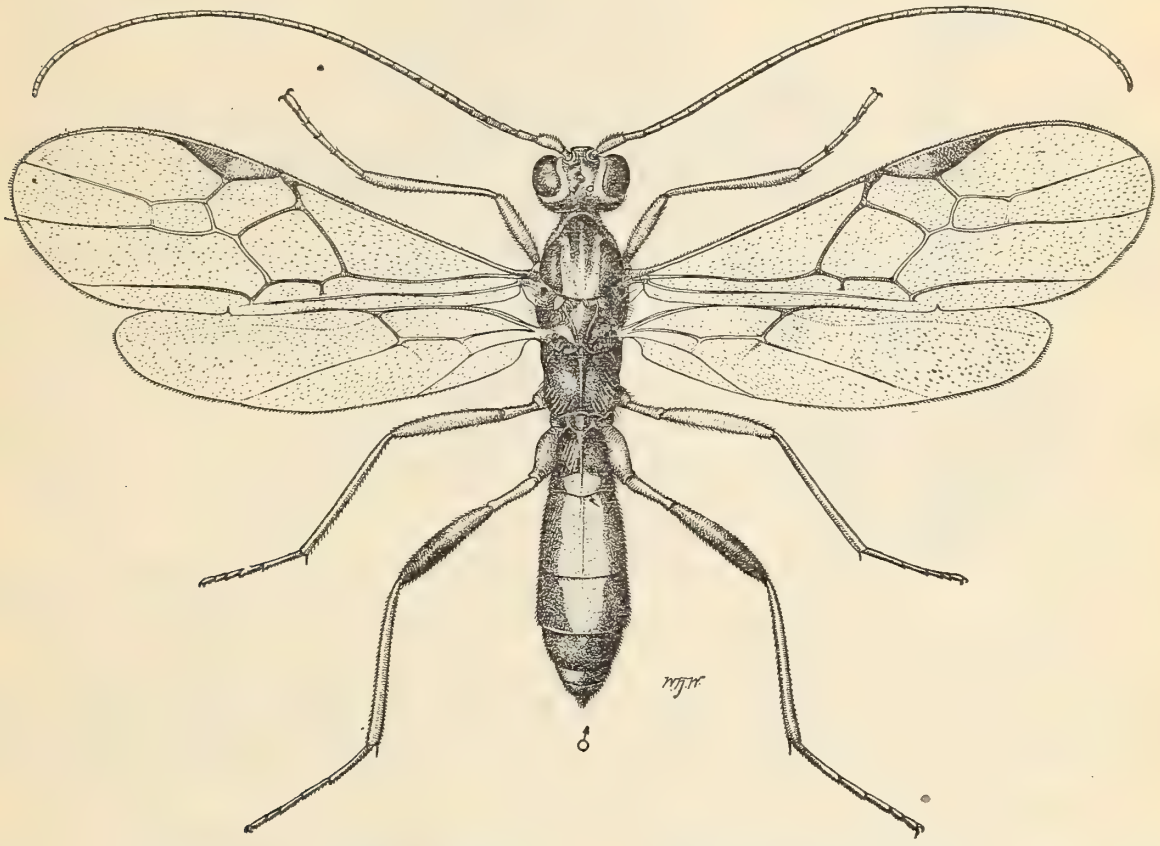

FIG. 46.—*Rhogas autographæ*, a hymenopterous parasite of the pupal stage of the alfalfa looper. Greatly enlarged. (Original.)

Microplitis n. sp., determined by Mr. H. L. Viereck, was reared from the larvæ of these moths on June 28, 1910. This parasite spins a tan-colored cocoon which measures 3.53 mm. in length (fig. 48, *a*).

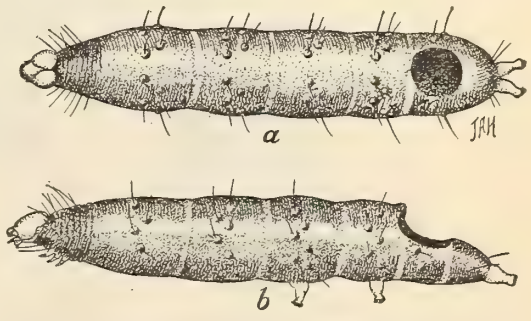

FIG. 47.—Larval skin of alfalfa looper from which *Rhogas autographæ* has issued: *a*, Dorsal aspect; *b*, lateral aspect. Enlarged 6 diameters. (Original.)

Sargaritis websteri Vier. is one of the most numerous parasites of the alfalfa looper at Pullman, Wash. The first specimen obtained emerged on August 14, 1909. The following year specimens emerged June 21, July 5, and July 25. This species spins a cocoon (fig. 48, *b*)

which is bluntly oval, mottled with brown, and measures 6.53 mm. in length.

On August 27 a dead larva of the alfalfa looper with a mass of hymenopterous cocoons fastened to it (Pl. XI, fig. 1) was found in an alfalfa field in Pullman, Wash. The cocoons were enveloped in a loose, white, silken ball 18 mm. in diameter. On August 29, 34 specimens of *Apanteles hyslopi* Vier. (fig. 49) emerged from this mass.

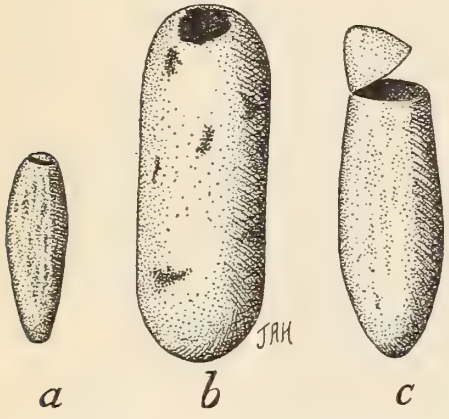

FIG. 48.—Cocoons of alfalfa looper parasites: *a*, *Microplitis* sp.; *b*, *Sargaritis websteri*; *c*, *Microplitis alaskensis*. Enlarged 5 diameters. (Original.)

Ameloctonus n. sp., determined by Mr. H. L. Viereck, was reared from the larva of this moth at Salt Lake City, Utah, in 1911, by Mr. T. H. Parks, of this office. The cocoon of the parasite was spun on August 17, and the adult parasite emerged on August 23.

One of the alfalfa looper larvæ in the insectary rearing cages started to spin a cocoon on January 11, 1909. On examining the cocoon two days later it was found to contain puparia of *Plagia americana* Van der Wulp, one entirely and one partly within the dried larval skin. On July 23 one adult emerged,

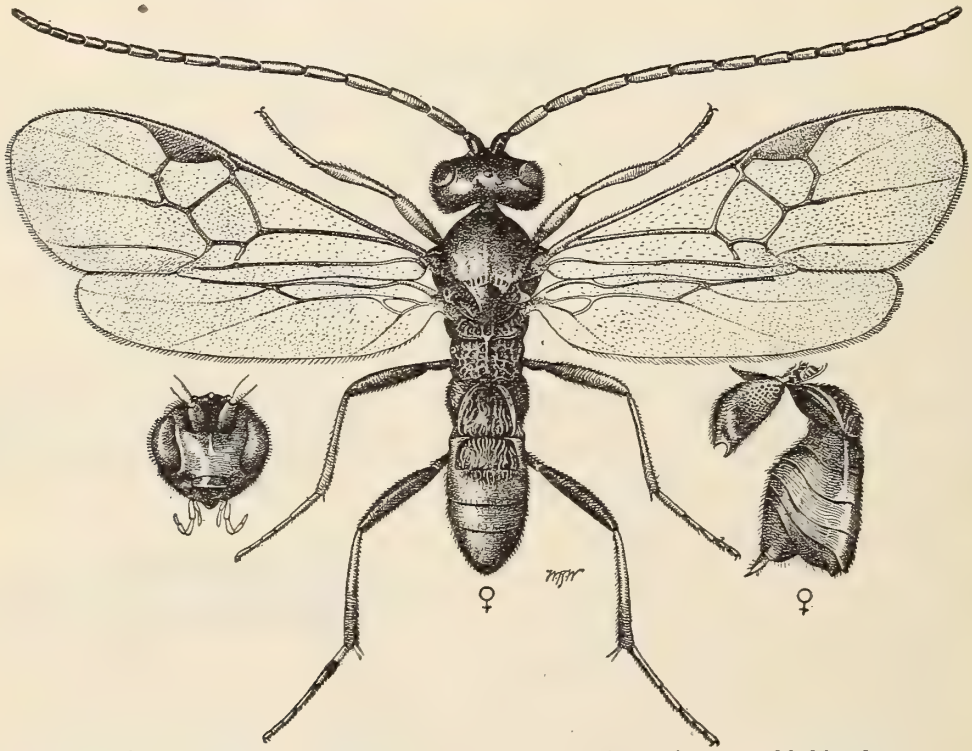

FIG. 49.—*Apanteles hyslopi*, a hymenopterous parasite of the alfalfa looper. Greatly enlarged. (Original.)

and on either July 24 or 25 another emerged (fig. 50). Several more of these flies were reared, and the number that would emerge from a larva was always directly associated with the size of the larva. A very small larva in our cages produced one fly, a medium-sized larva two, and a full-grown larva produced five of these parasites.

Two specimens of a dipterous fly, *Phorocera saundersii* Will. (fig. 51), were reared from a larva of the alfalfa looper on May 18, 1910.

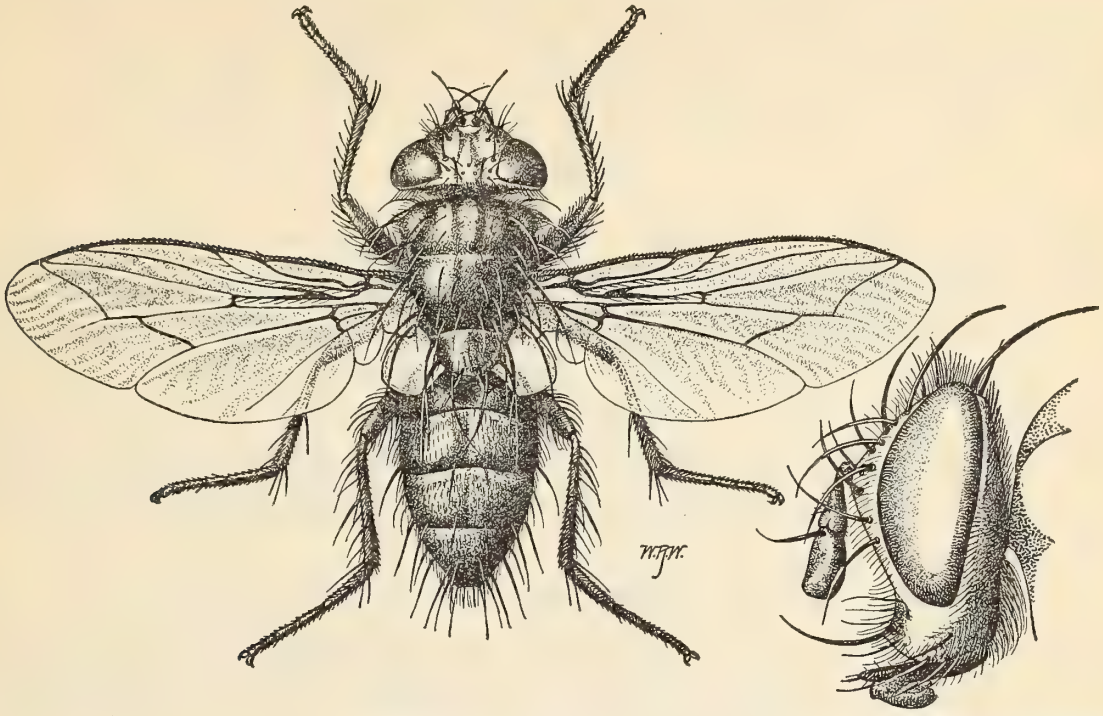

FIG. 50.—*Plagia americana*, a dipterous parasite of the alfalfa looper. Greatly enlarged. (Original.)

Mr. Koebele[1] records having reared 14 parasitic flies from a single larva of this moth at Los Angeles; but as the material is not now available, determination is impossible. These were probably not flies but Hymenoptera and very likely *Apanteles hyslopi* Vier. On

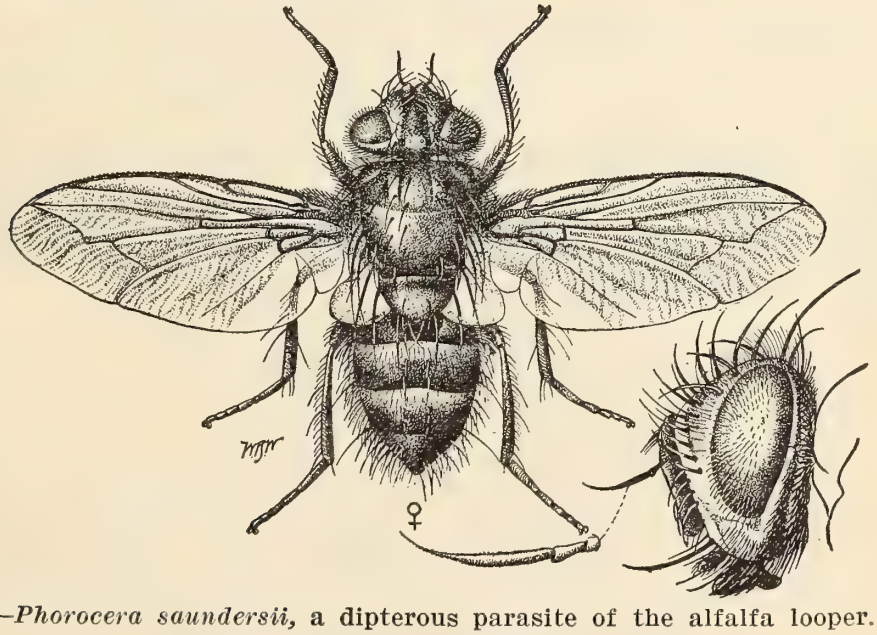

FIG. 51.—*Phorocera saundersii*, a dipterous parasite of the alfalfa looper. Greatly enlarged. (Original.)

the same note he also records rearing two flies from a larva of this moth at Alameda, Cal.

On July 8, 1909, two ants (*Formica rufa obscuripes* Forel) were found at Pullman, Wash., dragging a young larva of this insect that was alive and struggling.

[1] Bureau of Entomology Notes, No. 95 K.

Mr. T. H. Parks, of this office, also made a similar record near Salt Lake City, Utah, on August 16, 1911, wherein he observed a "number of large ants (*Formica subpolita* Mayr) dragging one of these half-grown larvæ to their nest in a field of alfalfa. The larva fought to free itself but was finally overcome and killed by the ants."

DISEASES.

Early in July, 1909, many of the larvæ in our rearing cages at Pullman, Wash., were killed by a disease. First, they became sluggish and contracted, and then turned dark brown, often being reduced to a black purulent mass. In other cases they became mummified. Specimens of these diseased larvæ were sent to Dr. Flora W. Patterson, Mycologist of the Bureau of Plant Industry, who reported that while she could find no fungi, the specimens were swarming with bacteria.

A note made by Mr. Theodore Pergande[1] February 21, 1883, records a fungous disease (*Botrytis rileyi*), having been found parasitic on *Plusia brassicæ*, by Mr. W. G. Farlow, of Cambridge, Mass.

REMEDIES AND PREVENTIVES.

Attention has already been called to the fact that in this species we have an illustration of the influence of natural enemies of a pest in protecting the interests of farmers by keeping the insect so reduced in numbers as to prevent injury to his crops. So effectually was this being done in the case of the present species as actually to prevent the conducting of experiments for warding off such injuries; hence no recommendations can be given. The time may come, however, when these natural enemies may themselves suffer reverses and temporarily fail to hold the pest in check; then the information here given will become of the utmost importance as a basis for experiments with restraining measures.

[1] Bureau of Entomology Notes, No. 294[02].

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